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WEEKLY 29 July 2023

SPECIAL ISSUE

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The biggest scientific challenges that AI is already tackling

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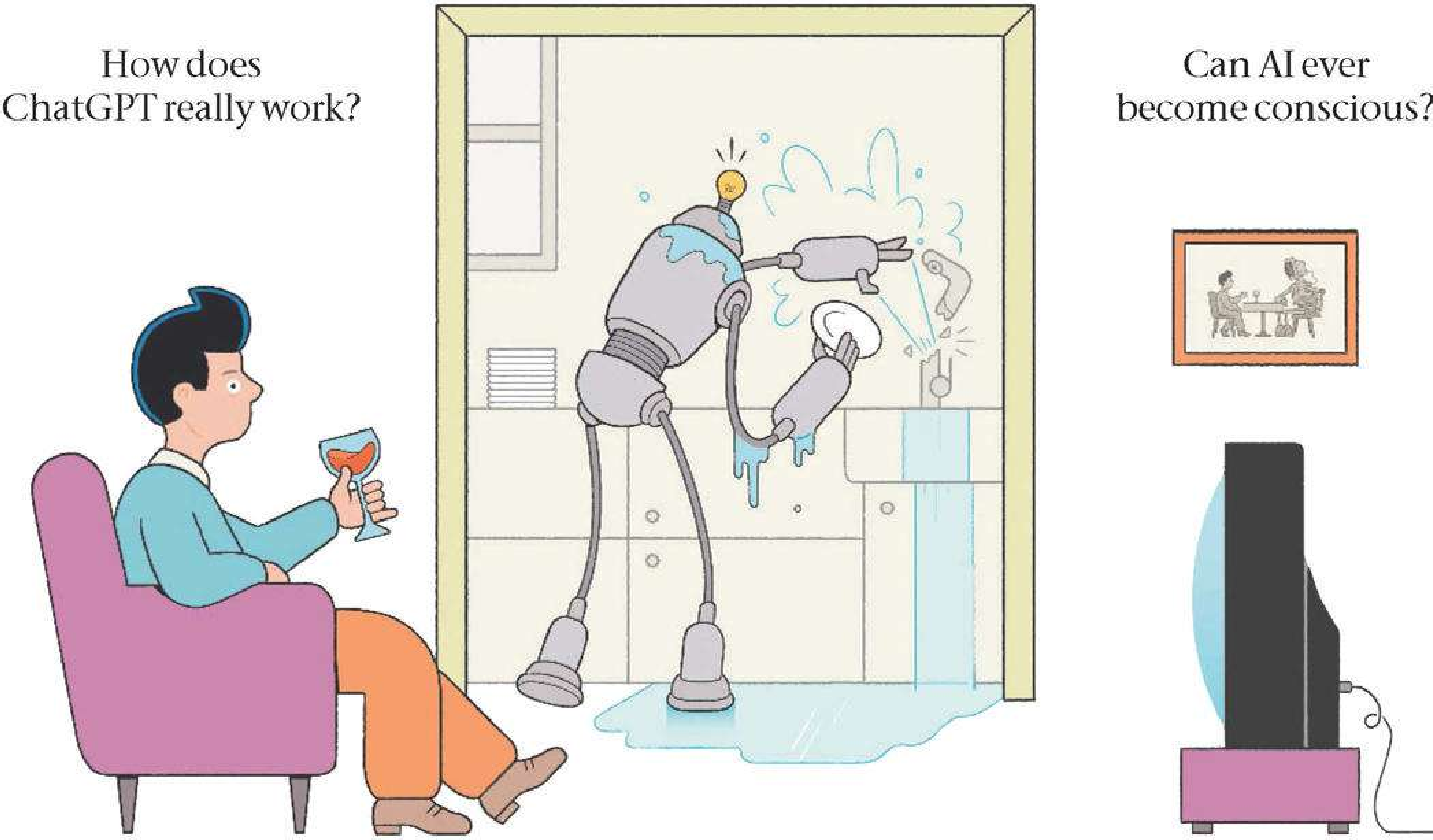
Can AI ever become conscious?



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This week's issue

On the cover

32 Living with AI
What the rise of artificial intelligence means for the world – and for you

Vol 259 No 3449
Cover image: Giacomo Gambineri

11 Eight lifestyle choices linked to living decades longer

6 Signs we may be facing a historically bad El Niño

41 The quest for a perfect sunscreen

7 Moon dust on Earth
9 Twitter becomes X
11 Fake bee blood
12 Two-faced star
28 Why we love owls

32 Features

> **"It'll be healthier if we keep AIs in their roles as tools, rather than as agents, like people"**

News

7 Psilocybin trials
Psychedelic drug shows promise treating anorexia

13 Basking in the heat
Basking sharks added to the list of warm-blooded fish

16 Turning turtles male
Splash of cool water on eggs could end male turtle shortage

Views

23 Comment
We need to curb our water use, says Jason Arunn Murugesu

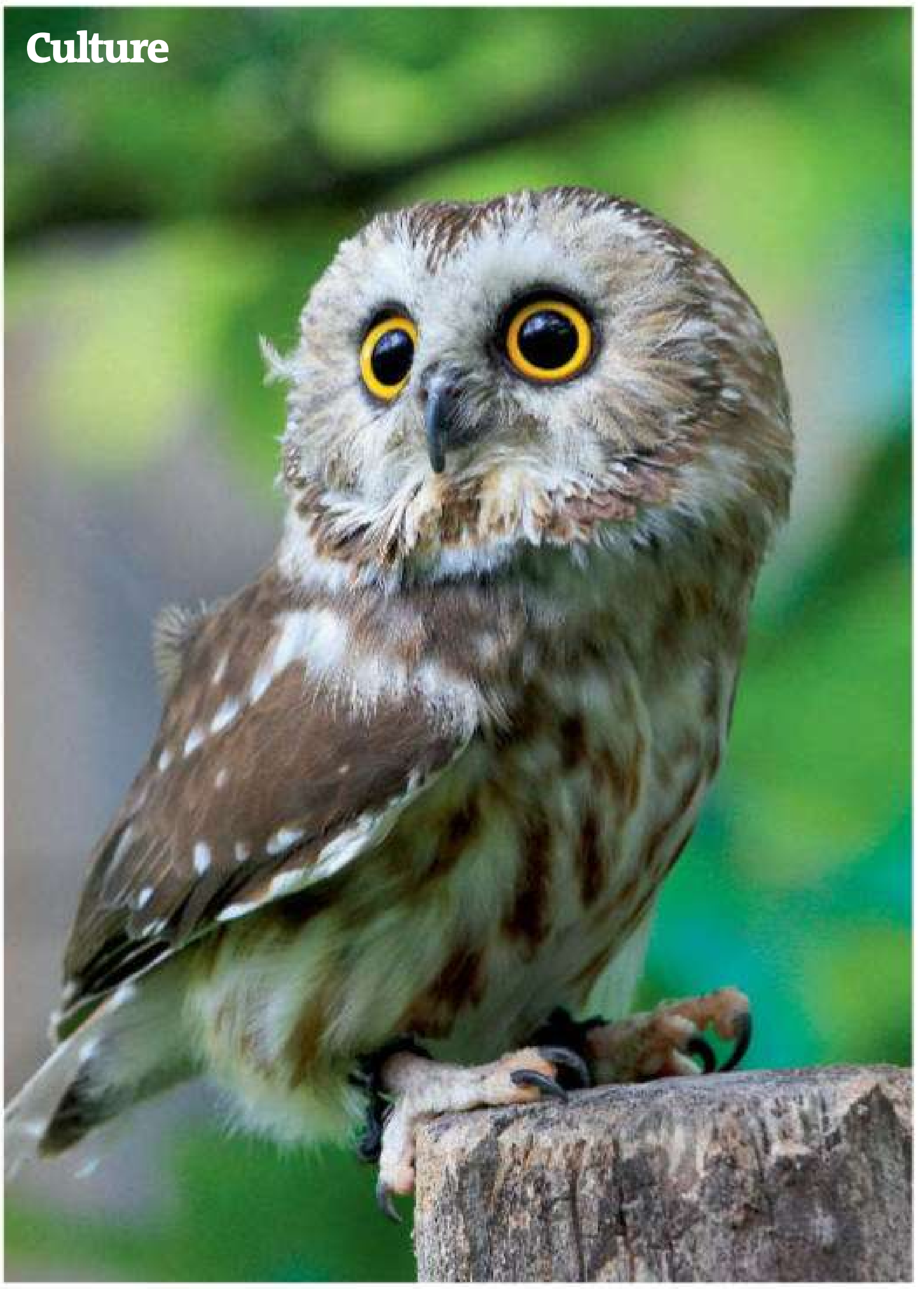
24 The columnist
Alex Wilkins on Elon Musk's mysterious AI start-up

26 Aperture
The tragic extent of deforestation in Bolivia

30 Culture columnist
Jacob Aron goes toe-to-toe with alien xenomorphs

31 Letters
Soya beans with pig protein could cause diet difficulties

Culture



ERICA RUTH NEUBAUER/ALAMY

28 Wise birds Why are humans so enchanted by owls?

Features

32 You and AI
How do AI chatbots really work? How will they transform the world? Can AI ever become conscious? What are the real risks it poses? And what can it do for you today? Our special report about life in the age of AI answers all the big questions

41 Supreme sunscreen
The slippery search for a safer and more effective sun lotion

The back pages

44 Science of cooking
How to make tempura

45 Puzzles
Try our crossword, quick quiz and logic puzzle

46 *Almost* the last word
Is it more sustainable to flush a tissue or put it in the bin?

47 Tom Gauld for *New Scientist*
A cartoonist's take on the world

48 Feedback
Scarecrow scare tactics and sheep-counting AI

Elsewhere on New Scientist

NS Live

You are electric: The new science of the body's electrome

Electricity plays a crucial role in your body that researchers are only just beginning to understand. Science journalist and author Sally Adee will take to the stage at New Scientist Live on 8 October to reveal new insights into the power of the electrome – from determining your shape in the uterus to its role in wound-healing and cancer.

newscientist.com/nslmag

Tour

The Science of Biodiversity: Costa Rica

Costa Rica covers just 0.03 per cent of Earth's land surface, yet is one of the most species-dense countries in the world. Accompanied by our intrepid local tour leader, you will delve deep into the science behind biodiversity, visiting cloud forests, wetlands, rainforests, volcanic zones and marine reserves. This 13-day tour begins on 6 November and costs £5749.

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Podcast

Weekly

This week, the team are talking about how nature beat us to an incredible Nobel prize-winning finding by billions of years. There is also a fascinating discussion about how fungi can help with your home improvements. Plus, there is a first-of-its-kind star that has two faces, and a new species of sabretooth cat.

newscientist.com/nspod

K. MILLER, CALTECH/IPAC

Two-faced Helium and hydrogen make up this unique white dwarf

JAKUB MACULEWICZ

Forest adventures Explore the biodiverse wonders of Costa Rica

Video

Activist anglers

Actor Jim Murray is best known for his role in TV series *The Crown*. Now, he has become an activist angler, pooling data about the health of Britain's rivers. Anglers keep a keen eye on water flow, temperature and habitat to know where fish are, says Murray, and this knowledge can be put to good use to save Britain's waterways, which are in desperate need of help.

newscientist.com/video

Newsletter

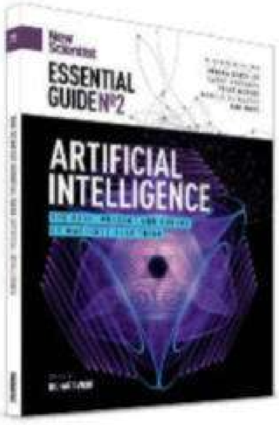
Wild Wild Life

Deep-sea hydrothermal vents are home to many weird and wonderful creatures, from snails covered in metal plates to hairy crabs. Eleanor Parsons explores the unusual adaptations that help them to survive with no sunlight, under extreme pressure and in water temperatures that range from boiling to freezing.

newscientist.com/wild-wild-life

Newsletter

> **"These yeti crabs grow microbes in strings that dangle off their hairy claws"**



Essential guide

With bewildering speed, AI has advanced to underpin many aspects of our lives. Questions abound: can AI ever be truly creative? What are the threats to society? And what is the economic impact of machine intelligence? This *New Scientist Essential Guide* offers these answers and more.

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AI-powered propaganda

Artificial intelligence brings myriad opportunities – but the risk to democracy is real

EAGLE-EYED readers will recognise this as our second special issue of the year on artificial intelligence. It is unusual for us to return to a topic so soon. But AI is moving so fast and attracting so much comment, from the insightful to the hysterical, that it is important to offer a clear-eyed look at the risks and opportunities it brings.

The first thing to say is that there is more to AI than the new generation of chatbots that have sparked the recent hubbub (see page 33). Different forms of the technology have already solved some serious scientific problems. Researchers have applied AI to everything from protein folding, which is revolutionising biology and drug development, to the quest for commercially viable nuclear fusion (see page 38).

That isn't to say generative AI, which creates text and images in response to human prompts, isn't useful. Forecasts suggest a general productivity boost from these systems could raise annual global GDP by 7 per cent (see page 34). If distributed equally, and not funnelled exclusively into the hands of shareholders, that could lift millions out of poverty and improve quality of life. We might all put generative AI to good use to save time on day-to-day tasks we might otherwise find tricky or tedious (see page 39).

> "AI's ability to amplify the spread of false information is in danger of being overlooked"

But there are risks, and here we must think clearly with regard to what to worry about. Rather than focusing on vague warnings of existential threats from a hypothetical super-intelligent AI, or even a conscious one (see page 37), we should pay more attention to extant problems.

One immediate risk in danger of being overlooked is AI's ability to amplify the spread of false information (see page 36). Distortion or fabrication of facts by AI could be accidental, due to sloppy safeguards, or it could come in the form of deliberate propaganda. In any case, with elections around the corner in both the UK and the US, surely the most pressing concern is AI's capacity to supercharge the distortion of democratic processes. The worry is that there seems to be precious little in place to combat the threat. ▮

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© 2023 New Scientist Ltd, England.

New Scientist is published weekly by New Scientist Ltd. ISSN 0262 4079. New Scientist (Online) ISSN 2059 5387. Registered at the Post Office as a newspaper and printed in England by Precision Colour Printing Ltd

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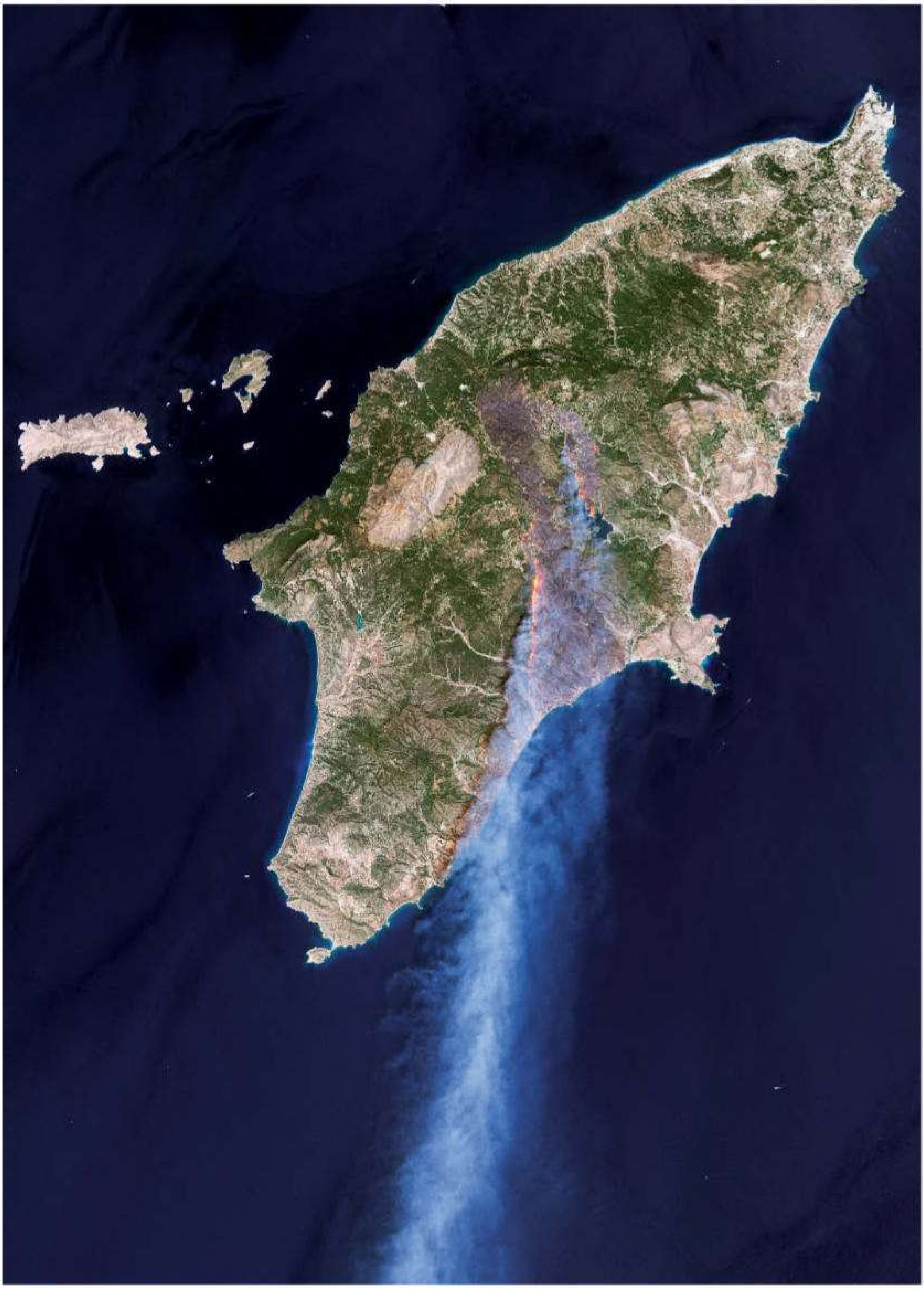
Able to remember
People can be more aware during CPR than we thought **p8**

Genetic favouritism
Your genes may affect how much fruit or salt you eat **p9**

Brain monitoring
Flexible probe reads signals deep inside rats' brains **p13**

Physics conundrum
Newton's first law of motion breaks at the quantum level **p15**

Maternal instinct
Older orca mothers protect their sons from conflicts **p18**



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Environment

Rhodes wildfires seen from space

Thousands of people have been forced to evacuate as wildfires spread from the mountains of the Greek island of Rhodes to the coast. A Copernicus satellite captured this image of the ongoing blaze on 23 July. The month is shaping up to be the hottest on record and an analysis has found that climate change made the heatwaves that have hit North America and Europe at least 1000 times more likely.

Environment

El Niño raises climate alarms

We don't yet know how strong the developing El Niño climate pattern will be, but even a weak one risks severe global disruption, finds **James Dinneen**

CARLOS GARCIA GRANTHON/FOTOHOLICA PRESS/LIGHTROCKET VIA GETTY IMAGES

MABELIN SANTOS/ALAMY

ADRIAN/INA PHOTO AGENCY/SIPA/ALAMY

El Niño could bring more mudslides in Peru (above) and affect water levels in Panama (top right) and rice harvests in Indonesia (bottom right)

THE possibility of a record-breaking El Niño climate pattern this year is causing alarm among climate scientists. Even a weak El Niño on top of human-driven global warming could have sweeping consequences for the climate, ranging from coral bleaching to flooding, and cost the global economy trillions of dollars.

"We have enough climate madness going on elsewhere without adding an El Niño to it," says Pedro DiNezio at the University of Colorado Boulder.

El Niño, which occurs when sea surface temperatures in the eastern tropical Pacific Ocean rise 0.5°C above the long-term average, arrived about two months earlier than usual in May, following three La Niña years. Historically, this cycle of surface temperatures – known as the El Niño Southern Oscillation (ENSO) – shifts between the warm El Niño state and the cool La Niña state every two to seven years, with neutral years in between.

In the years since the last strong El Niño in 2015-16, the Pacific has accumulated record amounts of heat, both from global warming and from natural oscillations in the ocean, says Michael McPhaden at the US National Oceanic and Atmospheric Administration (NOAA). The switch to El Niño means much of that heat goes back into the atmosphere. "The lid is off on the ocean," he says.

That heat has already begun to influence global weather, with predictions that it could make 2024 the first year global average temperatures surpass 1.5°C of warming. But the new El Niño is still relatively weak. The extent of its influence, and the severity of the consequences, largely depend on how much stronger it gets.

According to NOAA's latest projections, there is a greater than 90 per cent chance that this El Niño continues through to February next year. Its strength remains more uncertain, but Matthew Rosencrans at NOAA says there is a greater than 50 per cent chance it will be in the "upper echelon of strong category", and a 20 per cent chance it will rival the powerful El Niños of 1997-98 and 2015-16. "We could be in record territory," says Rosencrans.

What happens depends on how high the sea surface temperature gets in the tropical Pacific Ocean, as well as how the atmosphere responds. "ENSO is like a dance between the ocean and the atmosphere," says McPhaden. "Both partners need to be dancing to the same tune."

Generally, warmer waters weaken the easterly trade winds, which leads to more warming in the ocean. But despite the record amount of heat stored in the ocean, the winds haven't slowed much yet, says McPhaden.

Counterintuitively, one reason for El Niño's sluggish development so far might be climate change. DiNezio thinks warm waters in the western Pacific could be offsetting the impact of warmer eastern waters on the trade winds.

Whatever the cause, the longer it takes El Niño to strengthen, the less likely it is that it will reach historic strength this year. We should know by September, says Rosencrans. "There's not a lot of months left for this event to grow into a monster," says DiNezio.

"Due to global warming, what might be a heavy El Niño rain now becomes an extreme El Niño rain"

While a strong El Niño could be disastrous, even a relatively weak one could create more extreme weather, says McPhaden. Due to human-driven global warming, "what might be a heavy El Niño rain now becomes an extreme El Niño rain", he says. The same is true of drought and heat.

El Niño could also cause coral bleaching in the Great Barrier Reef due to warmer waters. Paulo Brando at Yale University is concerned drought driven by El Niño could make for an especially bad fire season in the Amazon.

That said, El Niño can bring beneficial effects. For instance, it could bring rain to the Horn of Africa, where drought, crop failures and conflict have made 32 million people food insecure, says Brenda Lazarus at the UN Food and Agriculture Organization. But too much rain could mean flooding, and El Niño could bring drought to other parts of East Africa.

Overall, El Niño is likely to have a negative effect, says Christopher Callahan at Dartmouth College in New Hampshire. He and his colleagues have shown that the climate pattern can have a huge economic impact, especially in lower-income countries. Depending on how much carbon dioxide we continue to emit, Callahan's team says an El Niño in the 21st century could cause as much as a 5 per cent reduction in global economic output. ▮

Mental health

Psychedelic drug psilocybin shows promise treating anorexia in early trials

Grace Wade

EARLY evidence suggests that psilocybin may help treat anorexia nervosa, an eating disorder characterised by distorted body image and food restriction. In a few small trials, people who took the psychedelic saw the severity of their eating disorder lessen.

Psilocybin, the psychoactive substance in magic mushrooms, has been shown to improve symptoms of depression, anxiety and addiction. These conditions share similarities with anorexia nervosa and often co-occur with it.

To investigate psilocybin's influence on anorexia nervosa, Stephanie Peck at the University of California, San Diego, and her colleagues gave 10 women with the condition a 25-milligram dose of psilocybin – enough to produce psychedelic effects. Psychologists guided participants through the session and discussed the experience with them later.

Before and after the trial, each participant completed the Eating Disorder Examination (EDE), an assessment that measures the severity of such conditions.

The researchers found that, on average, participants' concerns about weight and body shape improved by 24 per cent and 34 per cent, respectively, from the start of the trial to a month after. They also saw reductions in anxiety and preoccupations about food and eating. Additionally, 90 per cent of participants reported feeling more optimistic about their life three months after the treatment and 70 per cent believed their overall quality of life had improved (*Nature Medicine*, doi.org/kkwr).

45%

Reduction in severity of anorexia nervosa seen in psilocybin trial

However, the study was designed to only assess safety and didn't include a control group, which means it isn't known if the results are due to factors other than psilocybin, such as talking to therapists or the placebo effect.

But the findings align with preliminary data from two other trials presented at a psychedelics conference in Denver, Colorado, on 22 June.

Kate Godfrey at Imperial College London and her colleagues gave 20 women between the ages of 21 and 65 three doses of psilocybin over about a month. All participants had had an anorexia nervosa diagnosis for at least three years and were working with an eating disorder specialist.

The first psilocybin dose was 1 milligram to help participants acclimatise. The other two doses were 25 milligrams. Like the previous study, therapists guided participants throughout.

On average, the participants' EDE scores fell by almost 30 per cent from before the trial to two weeks after their final psilocybin session. So far, 14 participants have completed a three-month follow-up, and their EDE scores are, on average, nearly 45 per cent lower than before the trial.

In a separate study, Natalie Gukasyan at Columbia University in New York and her colleagues gave 18 participants with anorexia nervosa up to four doses of psilocybin alongside weekly therapy sessions. The results of this study won't be available until later this year, but she says they are finding improvements.

Existing anorexia treatments don't work for many people and these findings show there is a rationale to continue exploring psychedelics as therapy for eating disorders, says Yoel Golbert at Sheba Medical Center in Israel.

Larger studies are needed to show whether psychedelics do help though, says Gukasyan. ▮

Planetary science

Coating of space dust on Earth may come from the moon

A MYSTERIOUS layer of space dust that blanketed Earth millions of years ago could be shrapnel from asteroids that smashed into the moon, according to a new analysis of soil from below the sea floor.

In the 1990s, geologists found raised levels of helium-3 across Earth's crust, dating back to around 33 million years ago. This was puzzling because the isotope almost always appears only in objects from space, as a result of bombardment by cosmic rays.

Two large meteor craters dating from about that time – in Siberia, Russia, and Chesapeake Bay, US – led people to suggest that this dust may have come from a meteor shower, but the lack of other craters has made this difficult to prove. Plus, most objects larger than a few micrometres would burn up in Earth's atmosphere.

Now, Jörg Fritz at the Natural History Museum in Berlin, Germany, and his colleagues have evidence the dust came from impacts on the moon that fired dust into space before it settled on Earth. "When you have a shower of projectiles over Earth and they also hit the moon, then maybe, as the moon is the largest reservoir of helium-3 after the sun, it would be a good candidate [for the dust]," Fritz told the Goldschmidt geochemistry conference in Lyon, France, on 13 July.

NASA

Earth as seen by the Apollo 11 astronauts floating above the moon

The scenario would produce high levels of helium-3 and low levels of the element iridium, which the moon lacks, whereas meteors – which have more iridium – hitting Earth would deliver high levels of both elements. To test the idea, the team analysed soil samples from 2 kilometres below the sea floor in the Southern Ocean near Antarctica. The samples had low levels of iridium and high levels of helium-3, consistent with a lunar origin.

It is a neat suggestion and identifying the composition and age of lunar craters and linking them with soil samples on Earth could strengthen the hypothesis, says Thierry Adatte at the University of Lausanne in Switzerland. ▮

Alex Wilkins

Consciousness

Some people are aware during CPR

People may have more awareness during resuscitation than we thought, which could explain why those who survive sometimes report near-death experiences, finds **Clare Wilson**

ABOUT 4 in 10 people who survive resuscitation after a cardiac arrest seem to have had some kind of awareness during the process, perhaps due to blood returning to the brain – and this might be why people sometimes report strange visions afterwards, known as near-death experiences.

As a result, some doctors now say that people having cardiopulmonary resuscitation (CPR) may need to be given sedative drugs to avoid any pain or distress.

Some people who survive CPR report semi-mystical experiences, such as feeling like they are moving down a tunnel towards a light, meeting deceased relatives and even floating above their bodies looking down at the scene. "There are common themes," says Charles Deakin at University Hospital Southampton in the UK.

But such experiences could be caused by people hallucinating or dreaming as they recover afterwards. To investigate, Deakin's team recruited staff at 25 hospitals in the UK and US to study people who had a cardiac arrest in hospital and underwent CPR. The process, which can go on for half an hour or more, can include procedures such as chest compressions, artificial ventilation and electric shocks to restart the heart.

As the usual care team worked on the individual having a cardiac arrest, one of the researchers placed headphones on the person's ears to play them recordings. A small display screen was also placed above the person's head, showing images that faced the room's ceiling – to see if it is, in fact, possible for people to somehow look down on the scene from outside their body.

LISA MAREE WILLIAMS/GETTY IMAGES

A mock ocean rescue and resuscitation on Garie Beach near Sydney, Australia

People also had various forms of extra monitoring, such as electrodes placed on their head to record brain activity. Those who survived the cardiac arrest were questioned afterwards about any memories.

The team managed to carry out the procedure on 567 people who had a cardiac arrest. About 9 per cent of them survived and 28 of this group were able to be interviewed afterwards. Of these, 11 reported some kind of memory of the events or perceptions suggesting consciousness, giving an awareness rate of 39 per cent.

One insight came from the brain activity monitoring, which revealed that even after 40 minutes of CPR, almost half of the people had brainwaves that appeared nearly normal.

This could be because chest compressions start returning blood to the brain, says Deakin. "It has been assumed that where patients are in cardiac arrest there is no brain activity," he says. "Clearly, awareness is more common than we thought."

567

Number of people monitored for awareness while having CPR after a cardiac arrest

9%

Proportion of people who survived

39%

Proportion of interviewed survivors showing some awareness of events during CPR

Some of those interviewed reported what seemed to be clear memories, such as when they were being electrically shocked, as well as dream-like experiences during the resuscitation.

Six people's memories were classed as "transcendent" in some way. For instance, one person thought they heard their dead grandmother saying: "You need to go back." Another person felt they were standing next to the bed, rather than lying on it.

None of the 28 survivors who were interviewed could identify the image on the display screen that had been facing the ceiling. However, one person did identify the words that had been playing through the headphones (*Resuscitation*, doi.org/kkz3).

Three words – apple, banana, pear – were played five times. The patients were asked to state the names of any three fruits they thought had been said. One person correctly named all three. They could, however, have guessed the fruits by chance, acknowledges Deakin.

The rate of awareness during CPR could be lower in people who don't survive the process, because those who are successfully resuscitated would probably have had higher blood flow to their brain, says Deakin. "We don't know what people who haven't survived experienced."

Linda Dykes, an emergency medicine consultant in the UK, says the findings suggest doctors should give more consideration to sedating people undergoing CPR.

People are currently sedated only if they show signs of awareness, such as moving or groaning, which is estimated to happen in about 1 in 100 cases. "This should be a trigger to make us [think]: 'Should we routinely sedate during CPR?'," she says.

But Carl Waldmann at the Royal Berkshire Hospital in Reading, UK, says sedatives could lower a person's chances of being resuscitated. "I don't know that there's enough science yet to make definite recommendations."

Dykes says the study also highlights the need for doctors to discuss "do not resuscitate" plans with people who wouldn't benefit from CPR as their survival chances are so low. "The idea of someone being aware during a resuscitation attempt that is futile is horrific," she says. ■

Health

Your genes may influence how much fruit or salt you eat

Soumya Sagar

WHETHER you crave salty dishes or fruit, your genes may influence your food choices. Gaining a better understanding of how this varies from person to person could lead to bespoke food plans that help people make nutritious choices by taking genetic preferences into account.

Joanne Cole at the University of Colorado and her colleagues have previously identified 814 regions in the human genome that are associated with aspects of dietary intake, including how much fruit, veg, meat and fish someone eats.

The researchers wanted to understand if these regions directly or indirectly influence a person's food choices. "For example, genes that impact diabetes risk may also be associated with dietary intake due to disease management changes, like eating less sugar, and not because the gene is directly influencing someone's eating behaviour," says Cole.

She and her colleagues did a so-called phenome-wide association study for the regions. This involves taking a single genetic variant and seeing if there is an association with any traits, such as taste preferences, eating habits and health conditions. Each region was scanned for more than 4000 traits, using data from around 500,000 people in the UK Biobank study.

In work presented at the annual meeting of the American Society for Nutrition in Boston, the researchers identified 481 regions that seem to directly affect dietary intake through flavour perceptions and preferences. Foods and drinks most affected by these genes include salt, water, fish, alcohol and fruit.

"Consumers report flavour as the primary driver of food choice, therefore identifying how different people experience different flavours may be the key to personalised nutrition to improve healthy eating," says Cole. ▮

Briefing

Why is Twitter becoming X?

Elon Musk is once more plunging Twitter into turmoil by changing its very identity. **Chris Stokel-Walker** explains what's going on

NINE months after buying Twitter for $44 billion, Elon Musk is rebranding the platform. The name Twitter will be gone, as will its iconic bird logo. Musk is planning on renaming the platform X.

Why is Twitter being named X?

Who knows? Musk does have a fascination with the letter. It seems to have begun with X.com, the online payments company he launched in 1999 and made his fortune from after merging it with PayPal. Since then, he has launched SpaceX, while his electric vehicle company Tesla sells the Model X car, he named one of his sons X Æ A-12 and he recently launched an artificial intelligence venture called xAI.

What else will change?

The logo, for one thing: Musk held a competition to replace the Twitter bird logo with a new one. The winner was Tesla investor Sawyer Merritt, who offered Musk a logo designed for a now-discontinued podcast.

Twitter CEO Linda Yaccarino has tweeted (or should that be "xed"?) that "X is the future state of unlimited interactivity – centered in audio, video, messaging, payments/banking – creating a global marketplace for ideas, goods, services, and opportunities."

What that means is difficult to discern. It could be a nod to Musk's longstanding plans to develop an "everything app" in the manner of China's WeChat – something Musk said back in October 2022 his purchase of Twitter was an "accelerant" for.

"Claiming X will be the platform that can deliver everything forgets that the internet exists"

Some observers aren't impressed. "By claiming that X will be the platform that can deliver everything, [Yaccarino] is forgetting that the internet exists," says Steven Buckley at City, University of London. "The internet is the platform for everything."

Will this plan work?

Probably not. Everything apps, popular in China, involve giving access to large parts of your life to the people running them. The past few months of chaos under Musk may put off some people from allowing the firm to access their bank accounts.

For that reason, Musk will be relying on new arrivals. "If Twitter management is hoping to attract new people to the platform, they hope they are enough to replace the ones they continue to lose and alienate," says Om Malik, a prominent tech investor.

So should I move to Threads?

Meta's Twitter-like app, Threads, which launched earlier this month, would appear the most secure lifeboat for those looking to escape Twitter (or X). It has built-in integrations with Instagram and the team behind it has promised more features to compete with Twitter.

What about Bluesky?

The decentralised alternative to Twitter, started by former Twitter CEO Jack Dorsey, has its own issues, including content moderation snafus. In terms of users, it has largely been overtaken by Threads, which was able to tap into Instagram's existing network to reach 100 million users in just five days. Bluesky is still an invite-only app, and now has about 350,000 reported users.

Are there any other alternatives?

Tons. Mastodon was one early alternative, but remains the preserve of tech adherents, while Post.Social, Spill, T2 and others make up the pack.

But there isn't really a direct alternative to Twitter with all the features users love. Whether they care to stick around on X remains to be seen. ▮

Twitter's new X logo projected on its San Francisco headquarters

REUTERS/CARLOS BARRIA

Planetary science

Viking lander felt marsquakes

A reanalysis hints the Viking 2 lander was the first to detect quakes on Mars – in the 1970s

Jonathan O'Callaghan

NASA's Viking 2 lander probably discovered quakes on Mars almost 50 years ago, but this has only just been confirmed thanks to data from the InSight probe.

In 1975, NASA launched two missions to Mars, Viking 1 and 2, to study the planet's surface and search for life. Both probes were also equipped with a seismometer to hunt for marsquakes, tremors on the Martian surface similar to earthquakes, to see if they existed.

Viking 1's seismometer failed to operate, but Viking 2's worked for two years. While rudimentary, the instrument did pick up at least two signals that were thought to be quakes, one of which had a magnitude of 3.5. But mission scientists couldn't be sure if they were quakes or simply wind passing over the lander.

"We couldn't prove those two events," says Andrew Lazarewicz, who is now retired but was a graduate student on the Viking team. "It was very frustrating."

In 2018, another NASA lander called InSight was sent to Mars with a more advanced seismometer – "200,000 times more sensitive than ours", says Lazarewicz. The lander picked up more than 1300 marsquakes, the largest being a magnitude-5 "monster quake", proving their existence. It is believed that marsquakes are mostly caused by the planet cooling and its crust cracking, or by meteorite impacts, because Mars today isn't thought to have the tectonic plates that cause quakes on Earth.

Viking 2 studied the surface of Mars and tried to find signs of life there

NASA/JPL-CALTECH

Lazarewicz went back to data from Viking 2 and found that the events it recorded matched some quakes caught by InSight, all but confirming that Viking 2 detected the first marsquakes in the 1970s (*JGR Planets*, doi.org/kkv9). Back then, everybody was disappointed that the results were inconclusive, says Lazarewicz. "This is my way to repay the team. We did get marsquakes, and it was successful."

"The results are really fascinating," says Bruce Banerdt at NASA's Jet Propulsion Laboratory in California, the lead on InSight, which ran out of power in 2022. "It was a little puzzling that [Viking 2] hadn't seen anything."

"It's a very exciting, yet tentative, interpretation," says Simon Stähler at the Swiss Federal Institute of Technology in Zurich, Switzerland. More tests are needed to be confident in the result, he says, such as understanding the direction of travel of the recorded seismic waves.

The findings could be useful. Viking 2's landing site is about 3000 kilometres from InSight. Both are in the Utopia Planitia region. The source of Viking 2's marsquakes may have been Cerberus Fossae, a suspected site of former volcanic activity and the source of some of InSight's quakes, potentially hinting at tectonic or remnant volcanic activity in this region. "If Cerberus Fossae has been active since the 1970s, that… tells us something about the source of the activity, whether it's volcanic or tectonic," says Banerdt.

Benjamin Fernando at the University of Oxford says the findings could also tell us if marsquakes are seasonal. ▮

Nutrition

Plant-based milk has fewer key nutrients than cow's milk

MOST plant-based milks have lower amounts of protein than cow's milk, with nearly a third also having less calcium and vitamin D.

Plant-based milks have previously been shown to be low in four key minerals: phosphorus, magnesium, zinc and selenium. Now, Abigail Johnson at the University of Minnesota and her colleagues have analysed the nutritional labels of 237 milk alternatives made from almonds, oats, rice or soya beans that are available in the US or were until recently. They compared the protein, calcium and vitamin D levels to those of cow's milk, using a nutritional database.

On average, the plant-based milks had just 2 grams of protein per 240 millilitres, with a lot of variation between products, while cow's milk has 8 grams per 240 millilitres, regardless of whether it is skimmed, semi-skimmed or full fat. Protein is important for muscle growth, energy and digestion. The 19 per cent of plant-based products that matched or exceeded the protein content of cow's milk tended to be soya-based, says Johnson.

"It's important to be aware that swapping [cow's milk] for plant-based milk may not be a one-to-one substitution, even though that might be how you're using it," says Johnson. Still, most people get protein from other sources, such as meat, beans and legumes, she says.

Sixty-nine per cent of the plant-based milks were fortified with calcium and vitamin D. In these products, the calcium and vitamin D levels matched those in cow's milk. However, levels were lower in unfortified alternatives. Calcium and vitamin D both help to strengthen bones, while vitamin D also boosts the immune system.

"It's important to be aware that exchanging cow's milk for plant-based milk may not be a one-to-one swap"

The findings were presented at the annual meeting of the American Society for Nutrition in Boston. They are important because the nutrients are already underconsumed, says a spokesperson for the US Food and Drug Administration. ▮

Carissa Wong

Plant biology

Rare flower lures flies by making fake bee blood

Ryan Truscott

AN OBSCURE South African plant produces a fluid and scent that mimic honeybee blood to entice jackal flies to pollinate its flowers.

Jackal flies from the genus *Desmometopa* feed on the blood of insects, especially honeybees, that have been killed by spiders and praying mantises. They are alerted to the free meal by the smell of spilt bee blood, known as haemolymph.

Annemarie Heiduk at the University of KwaZulu-Natal, South Africa, wanted to know how and why the green, star-shaped flowers of *Ceropegia gerrardii* also attracted jackal flies.

She noticed that *C. gerrardii* flowers produce tiny droplets on their petals, so she and her team analysed the liquid and found that it contained a protein and sugar mixture similar to haemolymph.

The researchers also collected flower scent samples and analysed their chemical make-up with a mass spectrometer. They then attached electrodes to the flies' antennae and measured responses to the scent molecules. "If the antennae responded, that allowed us to say, 'Okay, the fly can perceive that particular compound'," says Heiduk.

Next, they placed small glass vials of solvent, containing combinations of scent compounds, on stakes in the ground within the plants' grassy habitat. With these, they could determine which mix attracted the flies, and they caught visiting flies to confirm they were the same species as those that visited the flowers.

The benefit of the subterfuge to the plants is clear: if the researchers kept flies from landing on wild-growing *C. gerrardii* flowers, the plants didn't produce any fruit (*New Phytologist*, doi.org/kkv4).

***C. gerrardii* is endangered, with only 2500 mature plants estimated to grow in grasslands threatened by invasive plants, fires and overgrazing.**

Health

Eight healthy habits linked to living decades longer

Grace Wade

REUTERS/CHRIS WATTIE

Moderate exercise is associated with longer life

PEOPLE who adopt eight healthy habits by the age of 40 may live about two decades longer than those who don't. The effect is lower, but still significant, for people who have these eight habits by the time they are 60.

Xuan-Mai Nguyen at the VA Boston Healthcare System and her colleagues collected data on physical activity, diet, sleep, mental health, relationships and alcohol use from more than 700,000 US military veterans between 40 and 99 years old. Participants completed a survey on their lifestyles between 2011 and 2019, and the researchers analysed this alongside data from health records.

During the eight-year study period, 33,375 participants died. After adjusting for factors like age, socioeconomic status and ethnicity, the researchers found eight habits that were correlated with a lower risk of dying from any cause during this period. These were eating a healthy diet, exercising, maintaining positive social relationships, managing stress, consuming alcohol in moderation, never smoking, sleeping well and not having an opioid use disorder.

Physical activity influenced longevity the most. Moderate exercise – equivalent to at least briskly walking a few blocks each day – was associated with a 46 per cent lower risk of dying during the eight-year time frame than being sedentary.

People without a history of opioid use disorder had a 38 per cent reduced risk of death in the period than those who did, and those who never smoked had a 29 per cent lower risk versus current or former smokers.

18

Extra years of life linked to adopting eight healthy habits

A healthy diet including mostly plant-based whole foods and stress management – determined by a low score on a post-traumatic stress disorder (PTSD) assessment – decreased the chances of dying during the period by about 20 per cent. The same was true for moderation when it comes to alcohol, defined as drinking no more than four alcoholic beverages in a day, as well as sleeping 7 to 9 hours a night. Positive social relationships had the least influence, lowering the chance of death in the time frame by only 5 per cent.

Using this information, Nguyen and her team modelled the lifespan of people who adopted all eight habits by the age of 40. Men and women would live almost 24 and 23 years longer, respectively, than those who didn't adopt any intervention. If people implemented the habits by the age of 60, they could extend their lives by up to 18 years.

"These eight lifestyle factors don't involve medications. Doctors don't necessarily need to be involved," says Nguyen, who presented the findings on 24 July at Nutrition 2023, the annual meeting of the American Society for Nutrition, in Boston, Massachusetts. "That is very powerful because it shows that individuals really can have a say over their future [health]."

However, Jenny Jia at Northwestern University in Illinois says it isn't always that simple. "There can be barriers at the community level, environmental level or policy level to adopting some of these lifestyle behaviours," she says. For instance, people in low-income neighbourhoods may not have access to healthy food options, which also tend to be more expensive and require more preparation time than less healthy alternatives.

Nguyen says it is also important to remember this is an observational study, so it only found associations, and we can't assume that the habits themselves extend lifespan.

Environment

Greenland's ice looks vulnerable

Sediment core shows that much of Greenland's ice could melt even if the world doesn't get warmer

Michael Le Page

A SEDIMENT core from under the Greenland ice sheet has provided the first direct evidence that much of the ice disappeared during an interglacial period 400,000 years ago, when global temperatures were similar to today's.

The findings show that even if the planet doesn't get warmer than it is now, ice loss from Greenland alone would add at least 1.5 metres to the global average sea level and possibly as much as 5 metres. This is in line with projections, but the study provides direct evidence to back them up.

"It's a pretty sobering warning that we not only have to stop putting carbon in the atmosphere, we've got to start taking it out if we hope to save Greenland's ice," says Paul Bierman at the University of Vermont.

He and his colleagues have been studying a core from Camp Century in north-west Greenland that was obtained in 1966 by drilling through the ice sheet.

NASA

Greenland's ice sheet contains enough water to raise sea levels by several metres

Camp Century, an abandoned nuclear-powered US military base, is about 200 kilometres away from the edge of the ice sheet and is on top of nearly 1.4 km of ice.

"They got to the bottom of the ice and they drilled 12 feet [3.6 metres] into the sediment below, which had never been done before and has never been done since," says Bierman. There was no way to date the sediment at the time and it was largely forgotten until 2018, when it turned up in a facility in Denmark.

Bierman's team used a technique called luminescence dating to show that the sediment was last exposed to sunlight about 416,000 years ago during an interglacial period in the British Isles known as the Hoxnian. "The only way the sediment could have been exposed to sunlight is if the ice was gone," says Bierman.

The researchers then used computer models to work out how much of Greenland's ice sheet must have melted or slid into the ocean for there to be no ice at the Camp Century site. At a minimum, Greenland lost enough ice to raise the global sea level by 1.5 metres and possibly by as much as 5 metres, the models suggest (*Science*, doi.org/gshn39).

During the Hoxnian, global sea level was up to 13 metres higher than it is today. It has been estimated that up to 6 metres of that was due to Greenland ice loss, but there has been no evidence for this until now.

"It is remarkable what they have extracted from sedimentary evidence," says Jonathan Gregory at the University of Reading, UK.

The average global temperature during the Hoxnian is estimated to have been between 1 and 1.5°C warmer than it was before the industrial age began – basically what it is now, says Bierman.

However, because the Hoxnian interglacial period lasted some 30,000 years, this study can't reveal how much time it would take to melt the ice. The Intergovernmental Panel on Climate Change projects that Greenland will contribute between 4 and 27 centimetres to global sea level by 2100, and more after that. ▮

Space

Strange two-faced star is a surprising cosmic rarity

ASTRONOMERS have found a star with a different composition on each side. Nicknamed Janus after the two-faced Roman god, the white dwarf is the first star of its kind ever spotted.

Jeremy Heyl at the University of British Columbia in Canada and his colleagues spotted Janus using the Zwicky Transient Facility in California, and then took more observations using several other telescopes. The data indicated that one side of the star was made up completely of hydrogen, and the other side completely of helium. It is more than 1300 light years from Earth and rotates about once every 15 minutes (*Nature*, doi.org/gshfwr).

We know that the entire surface of some white dwarfs can transition from helium to hydrogen and back to helium again, but we have never definitively caught one in the middle of this change before.

"It seems likely to be connected with a magnetic field in the star that's a bit stronger on one side than the other, but the data itself doesn't show evidence for a very strong magnetic field," says Heyl. "So we still don't completely understand what's going on."

If there is such a magnetic field, it would suppress the star's convection, or internal churning, only on the side where it is stronger. White dwarfs are made primarily of hydrogen and helium, so the lighter hydrogen would naturally float to the surface of the side with no convection, whereas on the other side the more abundant helium would bubble up to the top.

"If it was at the distance of the moon, it would look like one half is 15 per cent brighter than the other"

"If it was at the distance of the moon, you'd be able to clearly see these blotches from convection and it would look like one half is around 15 per cent brighter than the other," says Heyl. "Its temperature is about five times the temperature of the sun so it would appear incredibly dazzling to the eye."

The fact that we have searched so much of the cosmos and only found one of these stars means that they are probably relatively rare. ▮

Leah Crane

Health

Flexible probe reads signals deep inside a rat's brain

Chen Ly

RATS have been injected with a tiny, ultra-flexible probe that records the activity deep within their brains, bypassing the need for a surgical implant. The technology could one day offer an effective, minimally invasive way of monitoring and treating brain conditions in people.

16

The number of electrodes embedded in a tiny brain probe

Brain-machine interfaces are devices that are implanted into the brain to record its electrical signals and send them to a computer.

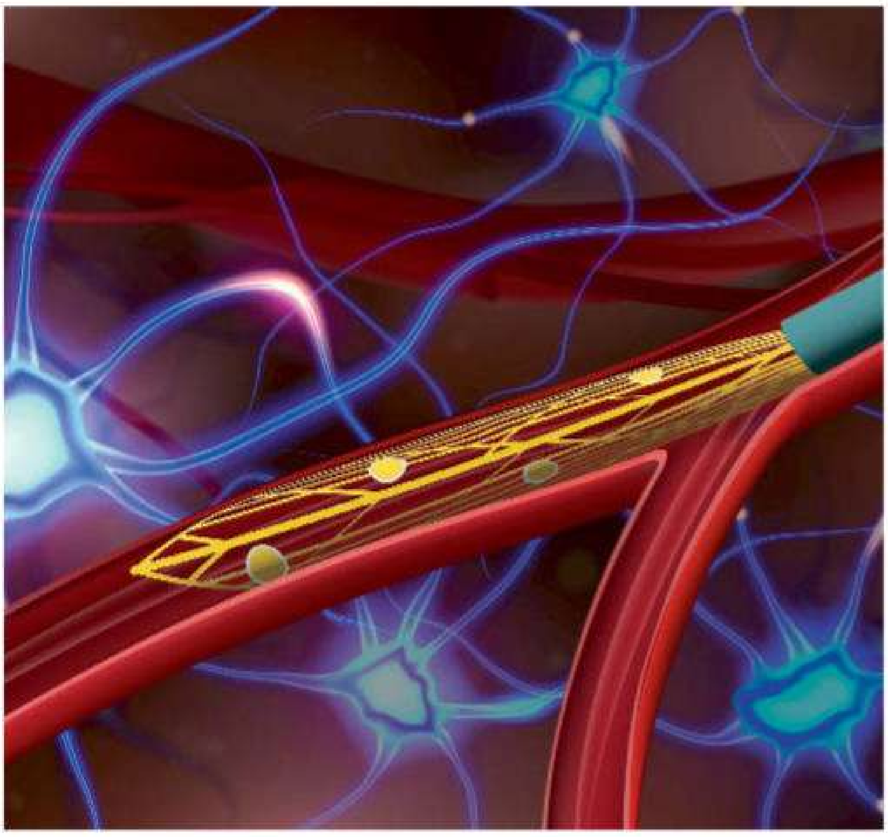
They can also be used for deep brain stimulation, in which electrodes produce electrical impulses to regulate abnormal ones. They have been central to neuroscience research and the treatment of neurological conditions, such as Parkinson's disease, says Charles Lieber, an emeritus professor at Harvard University.

Some of these devices use sensors placed on the scalp, but their recording resolution tends to be poor as the skull dampens the brain's electrical signals. To more accurately measure activity deep within the brain, electrodes can be implanted via open-skull surgery.

Now, Lieber and his colleagues have developed a device that may overcome the trade-off between an extremely invasive procedure and low recording resolution.

The blood vessels in the brain sit a few micrometres away from its neurons, making them a useful place to monitor brain activity. To create a device that can be moved through winding, microscopic blood vessels, the team used a flexible polymer to build a 7-centimetre-long mesh-like probe embedded with 16 electrodes.

The team tried the procedure on a group of rats. After making a small incision in a rat's neck, the team guided the probe to the base of the animal's brain using a 10-micrometre-wide catheter. After insertion into a blood vessel, the probe expanded and stuck to the vessel's walls, and its electrodes picked up signals from nearby neurons.



ANQI ZHANG, STANFORD UNIVERSITY

A probe (yellow) can be inserted into a blood vessel via a catheter

No side effects

By changing the width of the catheter, the team could insert the probe in a range of different blood vessels, with the rats experiencing no noticeable side effects (*Science*, doi.org/gshpcs).

The probe is small and is a prototype, so it contains relatively few electrodes, compared with around 1000 found in some surgical implants, says Lieber. The number of electrodes could be increased to improve its accuracy, but the device probably won't be used on its own when monitoring brain activity and conditions, he says.

The team now hopes to trial the technology in people, where it could eventually be used for monitoring brain signals in conditions such as epilepsy and Parkinson's disease. But it will take time to demonstrate the probe's safety and effectiveness in people, says Lieber.

The study could serve as a jumping-off point for inserting minimally invasive implants into blood vessels that enable access to brain regions with small, complex arrangements of blood vessels, says Salman Qasim at Icahn School of Medicine at Mount Sinai in New York. ▮

Marine biology

Basking sharks added to the list of warm-blooded fish

Melissa Hobson

BASKING sharks can maintain a body temperature that is higher than their environment, putting them among a small group of fish species that are warm-blooded.

When Haley Dolton at Trinity College Dublin in Ireland and her colleagues examined the anatomy of basking sharks (*Cetorhinus maximus*) that washed up on the shores of the UK and Ireland, they found several features in the muscles and blood vessels that would be expected from a warm-blooded fish like a great white shark, she says.

To investigate further, the researchers designed a new technique to record body temperature in a basking shark. The readings showed that the shark's body temperature was consistently about 1°C to 1.5°C above the ambient water temperature, suggesting that they are regionally endothermic – meaning they can warm up parts of their body (*Endangered Species Research*, doi.org/kkjf).

Regionally endothermic fish can migrate large distances in shorter amounts of time. Dolton and her colleagues believe this ability may also help the sharks overcome the drag caused by opening their large mouths while feeding.

"[This] completely changes what we knew about them and what they could be capable of," says Dolton. ▮

Basking sharks feed by filtering plankton from the water in their gill slits

NATURE PICTURE LIBRARY/ALAMY

Analysis **Energy transition**

High interest rates are stalling the green revolution

Failure to invest in renewable energy projects when financing was cheap means we will pay a much higher price to reach net zero, finds **Madeleine Cuff**

THE world's green energy transition, essential to achieving net-zero emissions and halting climate change, is under threat, as a financial era of rising interest rates has made some projects, like new offshore wind farms, unaffordable. Estimates suggest that Europe must now find an additional €163 billion to reach net zero by 2050, with figures likely to be similar elsewhere in the world.

Over the past 15 years, interest rates have been unusually low, making cheap financing accessible for companies to build green energy projects. The transition has been further boosted by the rapidly falling cost of green energy technologies, which has led many governments to withdraw subsidies altogether from some technologies.

But more recently, central banks around the world have been hiking rates in a bid to quell soaring inflation. In the UK, interest rates have risen from 0.1 per cent in December 2021 to 5 per cent last month, while the European Central Bank has raised the rate at which it lends to banks from 0.5 per cent in July 2022 to 4 per cent last month.

Rate rises aim to choke off spending across the economy, helping to dampen inflation. But the measures are also stymieing investment, with wind, solar and other green energy projects now struggling to get off the ground.

Market analysis from Dutch consultancy Berenschot, commissioned by the Netherlands Renewable Energy Association (NVDE), suggests rate rises in Europe since 2021 have already upped the costs of the energy transition until 2050 by €163 billion. The rising cost of capital will have a similar effect in other parts of the world.

Increasing interest rates is a "blunt tool", says Jens van 't Klooster at the University of Amsterdam, the Netherlands. "It brings down inflation, but then the cost of that in terms of lost investments are serious."

CHARLIECHESVICK/GETTY IMAGES

Wind projects have become more expensive to construct

There are also signs it is a tool that is no longer fit for purpose as we change our energy mix. Low-carbon energy infrastructure, such as wind farms, is costly to build but cheap to run, says Nick Robins at the London School of Economics. In contrast, many fossil fuel energy projects are relatively cheap to build but have higher operating costs. "The cost of capital is more important for net zero than the conventional economy," says Robins.

> **"The cost of capital is more important for net zero than the conventional economy"**

As such, firms are pulling back from new projects. In a presentation to investors in June, Mads Nipper, CEO of Danish green energy developer Ørsted, said the firm is making "active choices" to reconfigure projects as a result of rising rates. This includes Baltica 3, an offshore wind farm planned in the Baltic Sea, which Ørsted has postponed its final investment decision on.

"For some of these projects, quite honestly, we are going back to our major and most important suppliers, saying: 'You need to help us find additional cost savings that can improve these projects'," Nipper said. "We're also explicitly saying if we cannot get our projects to sufficient value creation, then therefore not be a responsible user of our investors' money, then we are prepared to walk away from these projects."

The trend is being felt across the entire green energy sector. In April, NVDE surveyed its members, spanning wind, solar, heat pump and electric car-charging firms, as well as grid operators. It found that almost one-third of respondents have already cancelled or postponed green energy projects because of the rate rises. "Rising interest rates are really damaging the energy transition," says NVDE chairman Olof van der Gaag.

On 20 July, Swedish energy firm Vattenfall announced it would stop work on an offshore wind farm in the UK's North Sea, warning that development costs for the Norfolk Boreas scheme had increased by 40 per cent due to rising interest rates and supply chain costs. "Although demand for fossil-free electricity is greater than ever, the market for offshore wind power is challenging," Vattenfall's chief executive Anna Borg said in a statement.

Raffaele Rossi at trade body SolarPower Europe says rising interest rates are a concern for the "bankability" of solar projects. "If the cost of debt is higher, the project's return on investment will be impacted," he says. This applies not just to solar power schemes, but also to manufacturing projects, such as plans to build solar panel factories. Financing support from governments and central banks is essential to ensure these schemes go ahead even in an environment of high interest rates, he says.

Van der Gaag says one option might be for central banks to implement a preferential "green interest rate" for renewable energy projects. In the 2010s, the European Central Bank operated a similar scheme in which banks benefited from lower interest rates if they lent more to households and non-financial corporations. This helped encourage banks to keep lending to the "real economy" during times of economic uncertainty. "The same kind of mechanism could be applied in a more focused way, specifically for investments in the energy transition," he says.

As with much climate policy, there is a sense of missed opportunities when it comes to interest rates. Governments should have done more to roll out low-carbon energy while financing was cheap, says van 't Klooster. "That's the big failure of the last decade," he says. "It would have been possible to fund a lot of these investments much more cheaply." ■

Physics

Newton's first law of motion seems to break down at the quantum level

Karmela Padavic-Callaghan

AN EXPERIMENT with light shows that one of the fundamental laws of motion may not always hold in the quantum realm.

Much of our understanding of how objects move stems from the laws of motion, laid down by Isaac Newton in the late 1600s. Newton's first law states that objects naturally move at constant speeds and along straight lines unless they encounter a force that pushes them to do otherwise.

However, for extremely small objects, Newton's laws must be swapped for analogous rules in quantum theory. In this case, determining exactly how an object moves is challenging because of the Heisenberg uncertainty principle, which says that the object's position and momentum can never be simultaneously measured with perfect precision.

Takafumi Ono at Kagawa University in Japan and his colleagues designed an experiment that takes this principle into account and tests whether moving along straight lines is a rule that can carry over from Newtonian physics into the quantum realm.

Their quantum object of choice was a photon, or a single unit of light, which they produced with a laser. They made it travel through several lenses and slits designed to give the photon momentum and position values that fell within a range of numbers allowed for by the uncertainty principle, before it hit a detector.

With this principle satisfied, they used an equation from quantum theory that mimics Newton's first law to predict what they would read from the detector, with the assumption that the photon had been moving along a straight line. Comparing these theoretical predictions to measurements from the experiment, they found a 45 per cent discrepancy. The findings will be published in *Physical Review A*.

"What we measured could not be explained by the assumption that quantum particles move along straight lines," says Ono.

Holger Hofmann at Hiroshima University in Japan says this finding is complicated by the fact that quantum laws typically only provide statistical information, such as the probability of something happening for many particles, while leaving questions about a single particle's behaviour unanswered.

"It is difficult to tell how this straight-line assumption breaks. It always works for averages, so how can it not work for an individual particle? We typically don't even have data for that case," he says.

For a photon, part of the solution may be to recast it as less particle-like and allow it to split or "smudge out" as it travels. But a lot more experimental work is needed to justify this perspective, says Hofmann.

Krister Shalm at the National Institute of Standards and Technologies in Maryland says the experiment highlights the differences between photons and quantum particles of matter. "If you talk about particle trajectories, and you want to talk about photons as particles, you can think of them as little balls bouncing around," he says, "but the consequence is that you're eventually going to get the wrong answer."

Materials

Fungi turned into eco-friendly fireproof sheets

RMIT UNIVERSITY

Sheets of compressed fungi after being exposed to flames

THIN sheets of compressed fungi have excellent fire-resistant properties and could be used as a non-toxic, biodegradable alternative to current fireproofing materials.

Flame retardant materials in use now, such as organophosphates, are considered safer than earlier ones like asbestos, but some studies have linked these modern alternatives with brain toxicity and harm to aquatic organisms.

Tien Huynh at RMIT University in Melbourne, Australia, and her colleagues have developed a more eco-friendly fireproofing material using mycelium – the root-like structure of fungi.

They grew mycelium from edible Basidiomycota fungi in containers of liquid molasses – a byproduct of sugar-cane refining. They also added sodium hydroxide to convert chitin, a component of the mycelium, into a substance called chitosan. The mycelium grew as mats on top of the molasses, which the researchers peeled off and dried before pressing them into millimetre-thin sheets (*Polymer Degradation and Stability*, doi.org/kkhd).

When they exposed the mycelium sheets to 800°C flames, the chitosan component quickly formed an outer layer of char that protected the rest of the sheet from burning, says Huynh. "The material caught fire for about one second then self-extinguished," she says.

The sheets only produced water and carbon dioxide when they were ignited, making them safer than existing flame-retardant chemicals, says Huynh. The team now hopes to develop fire-resistant cladding for homes and other buildings out of the fungi, which could be applied as a wallpaper-thin sheet or made into thicker, timber-like panels.

However, scaling up production could be challenging. "The fungi don't need light or electricity to grow, but they do need a big space if you want to grow enough for the building industry," says Huynh.

Alice Klein

Conservation

Splash of cool water could solve male turtle shortage

Alice Klein

MEL STAINES/WWF AUSTRALIA

Turtles' sex is determined by egg temperature

POURING some seawater on green turtles' nests may be a simple way to reverse a severe decline in male births that has been linked to global warming.

Over 99 per cent of green turtles (*Chelonia mydas)* that currently hatch on beaches in Australia's northern Great Barrier Reef, which is home to one of the largest populations of the turtles in the world, are female. Other species of sea turtle are facing a similar issue.

This is thought to be because rising global temperatures are overheating their nests. The sex of marine turtles is determined by the temperature at which their eggs are incubated, with warmer temperatures producing more females.

"This extreme feminisation is really concerning because if it continues, and there are very few males left to fertilise the females' eggs, we could see the end of important turtle populations," says Elouise Haskin at conservation group WWF Australia.

To try to address this problem, WWF Australia has collaborated with the University of Queensland, the Conflict Islands Conservation Initiative in Papua New Guinea, where there is a similar issue, and other groups to find ways to cool turtle nests down so that enough males are born to sustain the population.

Adult females make nests on beaches by digging a 70-centimetre-deep hole, laying about 100 eggs, then covering them with sand so they can incubate for around 55 days.

The researchers buried temperature loggers in green turtle nests on Heron Island in the southern Great Barrier Reef and Panasesa Island in Papua New Guinea.

They found they could cool the nests by 1.3°C by pouring 50 litres of seawater onto the sand above using a watering can. The seawater was collected from the shore the day before, allowed to cool overnight, then applied early the next morning.

Previous studies have found that nest temperatures above 28.7°C (83.7°F) result in mostly females hatching, but equal numbers of males and females develop at 28.1°C (82.6°F). That means the small amount of cooling achieved by adding seawater could theoretically be enough to rebalance green turtle populations, says Haskin, who presented the results at the annual meeting of the Australian Marine Sciences Association on the country's Gold Coast earlier this month.

A separate lab experiment found that a short period of nest cooling – for about threee to seven days – during the eggs' sex determination period was enough to produce some males.

There were initial concerns that adding seawater to turtle nests would dehydrate the eggs and impair their development, but this turned out not to be the case with the one-off seawater application, says Haskin.

99%

Proportion of green turtle hatchlings in the northern Great Barrier Reef that are female

Mark Hamann at James Cook University in Townsville, Australia, says "it is really vital research and I hope that it works", but "it may not be useful as a broad strategy at a beach scale when the clutches in the sand are all at different stages of the incubation cycle".

Haskin and her colleagues are now speaking to groups that manage important nesting sites in northern Australia to see if they are interested in trialling the cooling procedure on a larger scale. ▮

Astronomy

Planet may be the first known to share its orbit with another

Alex Wilkins

A WORLD that might still be forming in a distant star system seems to be muscling in on the orbit of a gas giant that is already there. If confirmed, this would be the first time we have seen two planets sharing an orbit.

While we know of many small asteroids that co-orbit with Jupiter, called trojans, and even some around Earth, these were probably captured fully-formed by the gravitational fields of these worlds, rather than forming in place.

Now, Álvaro Ribas at the University of Cambridge and his colleagues have glimpsed a dust cloud, which looks either like a planet taking shape or the remnants of one. This appears to be in the same orbit as the exoplanet PDS 70b, a gas giant seven times the mass of Jupiter, that is itself still in the early stages of formation.

To find the second planet, Ribas and his team used the Atacama Large Millimeter/submillimeter Array (ALMA) telescope in Chile to look at PDS 70b's Lagrangian points, gravitationally stable zones where trojan bodies might exist. They found a ball of dust around the mass of Earth's moon made up of centimetre-sized rocks (*Astronomy & Astrophysics*, doi.org/gshdrj).

"This orbital material is primordial, it formed with the planet. This dust and maybe gas have been gathered into the trojan point as the planet was growing," says Matija Cuk at the SETI Institute in California.

We currently only have a snapshot of the suspected planet, though it is in a position where we would expect it to be if it were co-orbiting. To confirm the discovery, we will have to wait for a follow-up observation in February 2026 and, to learn more about its composition, we might have to wait until 2030 for ALMA to be upgraded, says Ribas. ▮

Geology

GPS may one day predict quakes

An analysis of GPS readings taken prior to earthquakes has revealed a potential warning sign

Matthew Sparkes

EARTHQUAKES could theoretically be predicted 2 hours before they occur, saving countless lives – but we must first develop GPS sensors that are 100 times more precise than those in use today.

Over the past few decades, expert opinion has shifted on whether any telltale seismic signals exist prior to earthquakes, or if they are inherently chaotic and unpredictable events. Now, Quentin Bletery and Jean-Mathieu Nocquet at Côte d'Azur University in Nice, France, appear to have settled the debate.

The pair have used GPS data to identify a gradual, accelerating slip between tectonic plates in the lead-up to an earthquake. These slips are too small to appear on seismographs, but could – if detected – indicate when earthquakes are about to begin.

The researchers used GPS measurements gathered over a 5-minute period, making them accurate to within 1 centimetre, taken during the 48 hours prior to 90 separate earthquakes. With a combined data set of over 3000 measurements, they compared recorded ground movements with the expected direction of movement that each site would see during an earthquake.

In each case, they found that the largest movement in the expected direction occurred just prior to the earthquake. They also found that the last 23 data points showed a gradually increasing movement in the expected direction, and the final seven were higher than any others during the entire 48-hour period (*Science*, doi.org/gshpgs).

> "Expert opinion has shifted on whether any telltale seismic signals exist prior to earthquakes"

Bletery says that this is indicative of a gradual, slow and otherwise undetectable slip between tectonic plates that starts around 2 hours before an earthquake begins – something that could one day lead to a reliable earthquake detector.

But there is a problem. Bletery says that the noise levels of current GPS sensors mean that detection is only possible on the big data set, and not from any one site.

"We can't detect at the scale of one earthquake, so we cannot make predictions," says Bletery. "But it tells us there's something going on." Improvements to GPS sensors that allow them to detect movements of just 0.1 millimetres could make such predictions possible, he says. ▮

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Archaeology

Stunning stick was an ancient weapon

A WOODEN weapon, one of the oldest found, may have been thrown like a boomerang to stun animals. The 77-centimetre-long stick, pointed at both ends, was found in 1994 in Germany and has been dated to between 300,000 and 337,000 years old.

Annemieke Milks at the University of Reading, UK, and her team have studied it with modern imaging techniques. They found that it had been fashioned from the branch of a spruce tree, unlike other weapons at the site, which were made from trunks (*PLoS One*, doi.org/gshfw8). Branches are lighter and curved, says Milks.

The lightness of the wood, the fact it had a curve and it having been shaped so its centre of mass was displaced suggest it was meant to be thrown like a boomerang. **Jason Arunn Murugesu**

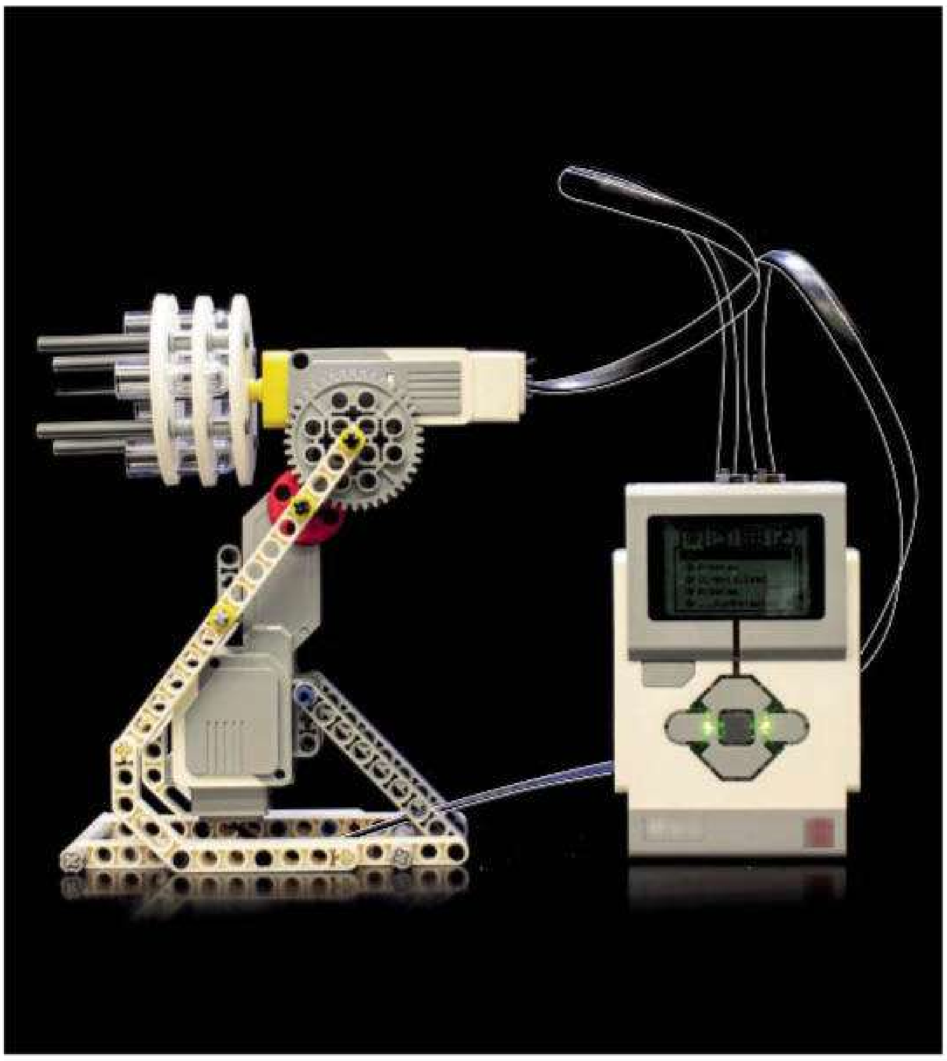
Animal behaviour

Older orca mothers protect their sons

FEMALE orcas that have gone through menopause continue to support their sons by protecting them from conflicts with other killer whales, suggests a study.

Orcas (*Orcinus orca*) are one of the few species that go through menopause. Charli Grimes at the University of Exeter, UK, and her team studied killer whales in the north Pacific and found that males with a postmenopausal mother had fewer tooth marks on their skin than males whose mother was still reproducing or dead. The same difference wasn't evident for female offspring.

As orcas are apex predators, these tooth marks are probably the result of conflict with other orcas. The findings suggest that a male orca's postmenopausal mother may play a key role in resolving these clashes (*Current Biology*, doi.org/kkhf). **Chen Ly**



SENTOSA ET AL., 2023, PLOS ONE

Technology

Lego device helps create molecular machines

A ROBOT made of Lego can quickly perform an important step for creating devices made of DNA.

"This started as a final project in an undergraduate lab course," says Rizal Hariadi at Arizona State University, who asked his class to build tools using "frugal science".

The robot one group of students made has proved particularly useful and resembles a single arm topped with a holder for cylindrical tubes. It performs a procedure to mix liquids in the tubes, first tilting them from vertical to horizontal, then rapidly spinning them around. This creates a single liquid with a density that uniformly decreases from the bottom to the top.

The robot's parts, including gears, connecting blocks and two motors, all come from Lego kits. The only exception is the tube holder that the researchers had to 3D print. The robot is a smaller and faster version of more traditional "gradient mixers".

After being mixed by the Lego robot, the liquid can be used for purifying tiny structures made of DNA molecules that researchers like Hariadi want to use as tiny machines. These machines could both carry out tasks inside cells and shed new light on how naturally occurring molecular machines, like proteins, work.

Many conventional methods for creating density gradients require hard-to-use and costly machines. The Lego one created the necessary density gradient in only 1 minute, which speeds up the purification overall (*PLoS One*, doi.org/kkhb).

Katherine Dunn at the University of Edinburgh in the UK says the robot could make the purification process both cheaper and quicker. **Karmela Padavic-Callaghan**

Really brief

CERN/SCIENCE PHOTO LIBRARY

LHC spawns new exotic particle

Researchers at CERN's Large Hadron Collider near Geneva in Switzerland have discovered a new type of particle called a strange pentaquark. The find could help us figure out how subatomic particles such as protons and neutrons are held together (*Physical Review Letters*, doi.org/kkfj).

Don't feel like dancing? AI can help

An artificial intelligence can create a video of you dancing from a single still image. The AI splits an image into the background, the foreground and the pose of the person in the shot, then morphs the person into different poses to create the dancing video (arXiv, doi.org/kkfk).

Ancient origins of Vietnamese curry

People may have cooked curries in South-East Asia at least 2000 years ago, according to evidence from freshly unearthed stone tools in Vietnam. Chemical analysis found traces of clove, turmeric, ginger, galangal, sand ginger, fingerroot, nutmeg and cinnamon (*Science Advances*, DOI: 10.1126/sciadv.adh5517).

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The evolving story of Alzheimer's disease

A better understanding of this devastating brain condition is raising the possibility of a new generation of management strategies

Sue Strachan doesn't fit the stereotype of a person living with dementia. "Unfortunately, most people's image is of someone old and hopelessly forgetful," she says. "I'm neither!" she says.

Strachan is an Alzheimer's Research UK champion who, since her diagnosis, has run a marathon and a half-marathon, abseiled from the UK's tallest sculpture and given numerous talks to the public and to researchers. So far, she has raised £30,000 for research, and she is excited about what is coming out of the world's labs.

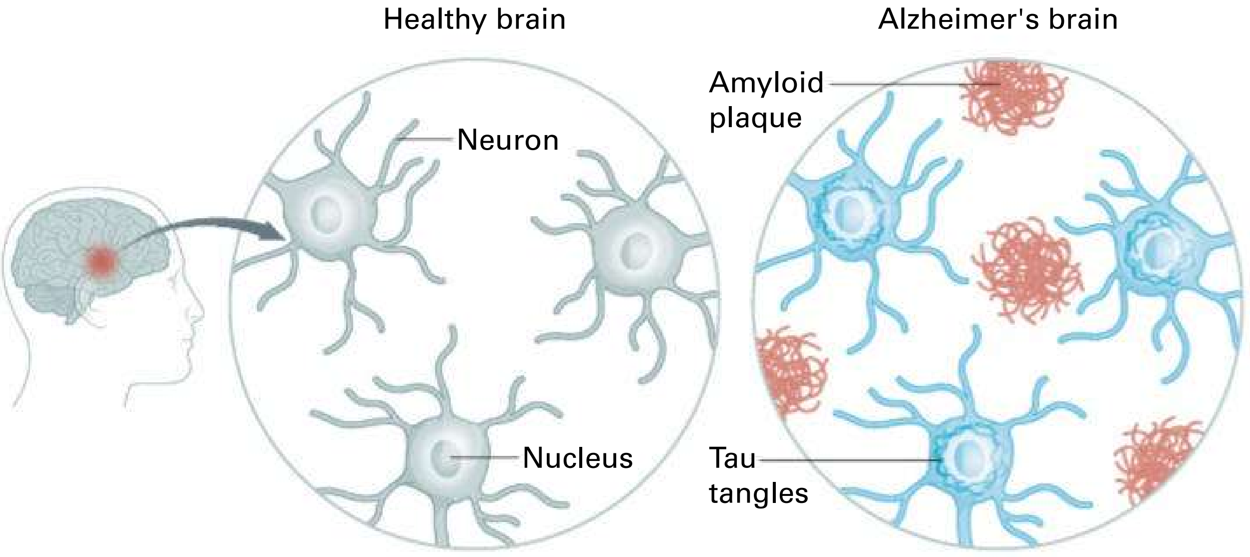
It's not just patients who are cheered. John Hardy, a professor at UCL in London, is also buoyed by progress: results from drug trials seem to finally validate the field's approach in the last few decades of research. "I'm pleased, but also relieved," he says. Christine Eksteen, Medical Director of the Tokyo-based pharmaceutical company Eisai, is similarly positive. "It's exciting– it's finally coming together," she says.

There are several reasons for all this optimism. One, according to Eksteen, is simply an unprecedented amount of collaboration. "Lots of big societies and research units are now working together to share data sets and information on how best to approach studies, and to analyse the data," she says. "The result is that we're starting to get a lot more understanding of how to go forward with research."

Another positive can be found in recently published research. After decades of disappointment, the results of a small handful of trials indicate that scientists might finally have found medications that can alter the progression of the disease. Alongside further research exploring exactly how these drugs work, and how best to administer them, researchers are also finding ways to diagnose the disease earlier.

There's no doubt that a breakthrough has been desperately needed. Alzheimer's

Alzheimer's research is focusing on amyloid and tau proteins in the brain



THE PROMISE OF BIOMARKERS

One of the most exciting prospects for Alzheimer's research is in finding new and easily accessible signatures of the disease carried in blood, mucus or saliva. That's important because patients need to be diagnosed quickly and easily before they can be treated.

Scientists and clinicians use imaging such as fMRI (functional magnetic resonance imaging) and PET (positron emission tomography). "Imaging biomarkers allow you to look at where and how much the brain has been affected," says Christine Eksteen, at Tokyo-based pharmaceutical company Eisai.

Additionally, examining cerebrospinal fluid via lumbar puncture can reveal how much amyloid and tau is being created, a useful marker of disease. But these are all somewhat disruptive procedures, and require significant resources in terms of staffing, equipment and cost. "There's a shift now towards less invasive ways of finding markers," Eksteen says.

Blood biomarkers are probably the most advanced of the new technologies. "They work in a research setting now, but are not quite ready for clinical practice," says John Hardy of UCL in London. He was excited to see that Alzheimer's Research UK has joined forces with some other organisations to start a £4.5 million "blood biomarker challenge": a funding programme to get blood-based tests for Alzheimer's to the point where they can be used in healthcare settings.

But developing a range of options for detecting excess tau and amyloid is the best approach, Eksteen says. "Drawing blood can be difficult in elderly people because their veins aren't as accessible: we're looking at the potential for using nasal swabs, and saliva too, which would be less invasive."

disease is the most common form of dementia, where people – usually, but not exclusively the elderly – gradually become more forgetful and confused. Around 35 million people worldwide currently have Alzheimer's disease, a devastating tragedy for them and their loved ones, and a significant burden on healthcare services. "It sometimes seems that everybody knows someone who has, or had Alzheimer's," Eksteen says. She remembers watching her once-vibrant grandmother succumb to the disease, an experience she describes as "awful".

For decades now, scientists have hypothesised that Alzheimer's disease is associated with excessive amounts of two proteins known as tau and amyloid. They know that if people carry a particular variant of a gene called ApoE, which is known to raise amyloid levels, this significantly raises their risk of developing Alzheimer's. They also know that amyloid clumps together into plaques, and tau clumps together to form "tangles" in the brains of Alzheimer's patients. But they have never been able to show the cause-and-effect relationships in motion.

However, current research supports the idea that reducing the build-up of these proteins in the brain may alter the progression of cognitive decline. This is actually the first sign that these proteins and Alzheimer's are related. "That's a really important step forward," Hardy says.

Hardy is also excited about a therapeutic approach known as antisense strategy that aims to inhibit the action of specific biological molecules inside the body. The latest results involve antisense molecules that target the tau protein. One of the processes behind Alzheimer's seems to cause excess production of tau, which accumulates in "tangles" that block communications between neurons. The new antisense strategy successfully reduced levels of tau. "This may be showing the first benefits of anti-tau therapy," Hardy says, adding that this points to the possibility of combined therapy that targets more than one biomarker.

> **"Earlier diagnosis is one of the objectives of biomarker research in Alzheimer's"**

Alzheimer's is a huge burden for patients, their families and for healthcare systems

HAYDENBIRD/ISTOCK

That said, there is plenty left to do before therapies become widely available. "It's the first step on a very long journey," Eksteen says.

One puzzle involves the brain's specialised immune cells called microglia and how they might be involved in Alzheimer's. Normally, the microglia regulate, maintain and repair networks of neurons. They also help to clear excess amyloid and tau in brains functioning normally. But in Alzheimer's patients they seem to play a problematic role, causing inflammation and cell damage.

Researchers would also like to investigate why some patients receiving medicines in clinical trials have suffered adverse effects such as swelling, bleeding and even strokes. Hardy reckons that the problem is the result of these medicines targeting proteins in blood vessels first. This seems to provoke an inflammatory reaction that might be avoided if patients were treated before excess production raised the levels of these proteins in the first place.

Earlier diagnosis is one of the objectives of biomarker research in Alzheimer's: if researchers can find ways for a blood test, nasal swab, or even saliva analysis to reveal the disease before cognitive symptoms appear, they might be able to intervene and halt disease progression. Things are looking positive in this area, Eksteen says (See box).

All in all, recent advances are small steps – but important ones, Eksteen says. "We're beginning to understand the disease, we have biomarkers, and researchers collaborating, we have data that we can draw on, and the ability to do studies in a more targeted way. We can choose the right patients to come into the studies so you can really analyse the risks and benefits of a drug."

This progress is also providing hope for people living with dementia like Sue Strachan. "There are so many strides forward being taken," she says. "I have quite a few friends who are living with dementia, and we are all optimistic."

Find out more about Eisai EMEA at: www.eisai.eu

Eisai commissioned and funded this article.
It also had editorial input.
EMEA-NON-23-00097
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Views

The columnist
Alex Wilkins on Elon Musk's mysterious AI start-up p24

Aperture
The tragic extent of deforestation in Bolivia p26

Culture
Why are humans so enchanted by owls? p28

Culture columnist
Jacob Aron goes toe-to-toe with alien xenomorphs p30

Letters
Soya beans with pig protein could cause diet difficulties p31

Comment

Turning off the taps

For me, learning about river neglect and water waste was a wake-up call. We need to change habits now, says **Jason Arunn Murugesu**

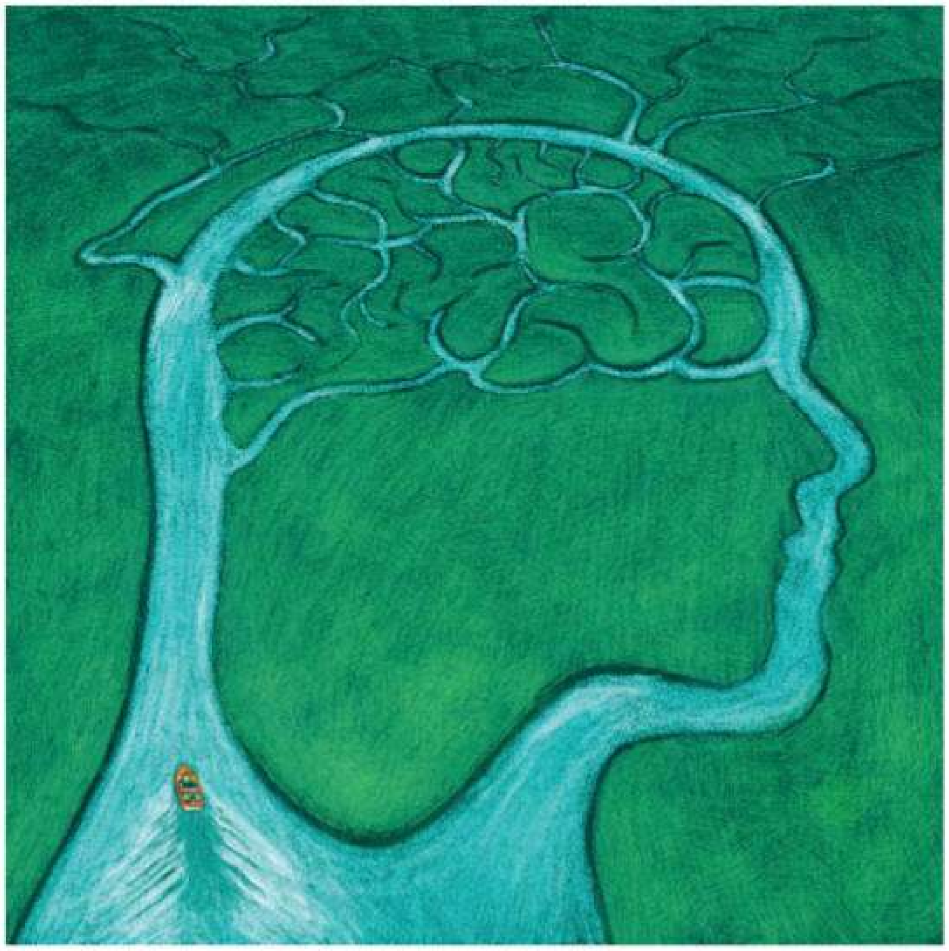
FOR most of 2023, I have been immersing myself in all things river-related for *New Scientist*'s Save Britain's Rivers campaign. I have written about sewage pollution, the state of the country's river-monitoring systems and the fact that hundreds of tonnes of oxygen had to be pumped into the Thames last summer to prevent the river's fish from dying.

The topic was completely new to me. My background isn't in environmental science: I studied neuroscience at university and, until this year, had largely covered biomedical stories.

I also wasn't someone who particularly cared about the environment. OK, I did care about the environment, but I didn't care in the same way that many of my colleagues and I am sure many of you do. I still don't think too much about whether I can recycle a crisp packet or not. I don't help out in my local community garden or avoid plastic packaging. Am I even allowed to admit this?

One thing I never thought about before this year was the plight of rivers. I grew up in London. I know one river. It's big and beautiful and it's called the Thames. What else is there to know? Feargal Sharkey, the former lead vocalist of The Undertones turned river-activist, says there is too much sewage being released into UK rivers. So what? I don't swim in them. There are bigger issues in the world.

But this year, my eyes have been opened. Rivers are a vital ecosystem that we are completely neglecting, and there is one aspect of this topic that I find particularly alarming – how much water we all use without thinking.


SIMONE ROTELLA

I don't think I really understood that so much of our drinking water comes from rivers. I didn't know that when water companies enforce hosepipe bans, they are partly doing so because they can't remove any more water from a river without causing severe environmental damage.

We use a lot of water. In England, households use 144 litres of water per person per day. As a point of comparison, in Denmark, the value is only about 104 litres per day. According to the UK National Infrastructure Commission, England will need an additional 4 billion litres of water each day by 2050 due to climate change and the country's rising population.

But we currently don't have the infrastructure to meet this demand. No new reservoirs have been built in the UK for more than 30 years. Around 20 per cent of the public water supply is lost through leaks.

To keep up with demand, at least in the short term, water firms largely plan to take even more water from our rivers. But this can be ecologically devastating and is generally not a sustainable option. To help ease pressure on the system, the UK government wants people to cut the amount of water they use each day to 110 litres by 2050.

This may be achieved in part if we all start buying the most water-efficient toilets and sinks, which the government hopes to encourage by introducing water-efficiency labels. But beyond plans made by water firms and the government, we all need a major shift in how we view water.

We take water for granted. I have multiple baths a week. A full bath uses about 80 litres of water. Are we all washing our dishes in the most efficient way? Is there a better way to water our gardens?

This is important. Droughts are becoming more common in the UK. If we don't ask these questions today, we may be forced to take far more drastic action later. It has already happened elsewhere: in 2018, residents of Cape Town, South Africa, were limited to just 50 litres of water per day due to severe drought.

We need new reservoirs. We need water firms to cut their water leakage rates. But we also need to stop thinking of water as cheap. We don't have an unlimited supply. ▮

Jason Arunn Murugesu is a reporter at *New Scientist* @ajmurugesu

Artificially intelligent

Universal questions Elon Musk's latest venture is an artificial intelligence start-up. Perhaps this is exactly what the world needs to tackle the big questions, writes **Alex Wilkins**

Alex Wilkins is a *New Scientist* reporter covering artificial intelligence, physics and space. Artificially intelligent is a column that cuts through the hype and looks at what AI is really capable of and what it means for us. You can follow him @AlexWilkins22

Alex's week

What I'm reading

The Door *by Magda Szabo, a brilliant, mysterious novel about the relationship between a writer and her housekeeper in Hungary.*

What I'm watching

I have been glued to the summer's sporting events: The Ashes, Wimbledon and the Tour de France.

What I'm working on

I have been following up on research leads from the Goldschmidt geochemistry conference in Lyon, France.

This column appears monthly. Up next week: Annalee Newitz

ELON MUSK, not content with helming recent purchase Twitter alongside SpaceX and his other long-standing firms, has announced an artificial intelligence start-up called xAI. People have speculated that it might be an attempt to challenge OpenAI's ChatGPT, an AI-powered chatbot that has grown to 100 million monthly users in the blink of an eye. But a veil of mystery hangs over the venture, whose goal is "to understand the true nature of the universe". Musk isn't averse to grandiose statements and marketing bluff – a SpaceX mission to Mars is seemingly always just on the horizon – but a well-funded firm tackling the big questions could be just what AI needs.

Academics in the field complain their ability to do experiments and work with the smartest minds is hampered by the private sector, with investors throwing billions of dollars at promising start-ups. Universities can't compete with the salaries or computational firepower of companies like Microsoft, so big-money moves out of public institutions are commonplace. This has arguably become worse since the release of ChatGPT. The move signalled to companies like Google that, instead of doing fundamental research behind closed doors, the priority should instead be commercialisation, which led to the release of the Bard chatbot.

Although academia has its own idiosyncrasies and research preferences, it is still less attached to direct commercial interest than big tech and more open to science. But if resources are pooled in firms, then basic questions may never get looked at, let alone solved.

So when I read that Musk was starting an AI company that might take on the big questions, I felt a glimmer of hope. Putting aside his sometimes bizarre online antics, consistent overpromising and flirtations with fringe right-wing politics on Twitter, Musk has a successful track record of running companies, namely SpaceX and Tesla. Maybe xAI will succeed.

Information is scant on what, exactly, the 12 researchers Musk has hired will be working on, so I decided to look at their past research to get a better sense of the company's possible future.

Last year, I interviewed one of the team, Yuhuai Wu, for his work on using AI to translate maths problems from plain English into a machine-readable format. Wu, working at Google at the time, was supervised by Christian Szegedy, now also at xAI, who oversaw a team looking at how to solve maths problems with AI more generally. Szegedy has predicted that a computer will match the capabilities of the best human mathematicians by 2026.

> "Academics in AI complain that their ability to work with the smartest minds is hampered by the private sector"

Other xAI employees, like ex-Microsoft engineer Greg Yang, are experts in the underlying mathematics of neural networks, the architecture that powers AIs like ChatGPT, or have worked on creating more general-purpose AIs, like Jimmy Ba, whose self-described research goal is to build "general problem-solving machines with human-like efficiency and adaptability".

Not all of Musk's new employees deal with the theoretical. Some, like ex-DeepMind employee Guodong Zhang, were involved with more commercially applicable ventures, such as the Gemini chatbot – DeepMind's cross between GPT-4 and problem-solving AIs like its chess and Go-playing AlphaZero. The xAI team is also advised by Dan Hendrycks, the director of a non-profit organisation that focuses on AI safety.

Together, the team has the technical nous to probe questions such as whether maths can be conquered by machine. Musk's interest in moonshot projects – like human-machine interface start-up Neuralink – is a bonus, too. xAI will work closely with Twitter and Tesla, whose massive computational resources are likely to be far beyond what any university might be able to offer.

But it might all go horribly wrong. Musk often expounds confidently on matters of reality in which he is no expert. Last week, as well as announcing he would rename Twitter as X, Musk responded to a proposal that the universe is twice as old as thought, writing on Twitter that "dark matter is what seems most sketch to me". Astrophysicists quickly responded that dark matter is one of the most well-supported, though unexplained, phenomena in all of physics.

Understanding the "true nature of the universe" might just be cover to build a chatbot that is free to be politically incorrect. At a launch event for xAI, Musk said that AIs, like ChatGPT, could be "incredibly dangerous" because false outputs might lead to real-world harm. The only way to counter this harm, he says, would be to build a "maximally truth-seeking" system. If this is what Musk means by understanding the universe, then the future will be a lot less interesting. ▮

See our AI special on page 32

ADVERTORIAL

THE HIDDEN PLASTIC POLLUTION PROBLEM, THAT IS ENTIRELY PREVENTABLE

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FALCO MARTIN
Programme Officer, Marine Plastics, Fauna & Flora

Seabirds and marine life being devasted by ocean plastic pollution frequently hits the headlines. Images of animals tangled in strapping bands and fishing gear, or their stomach filled with plastic bags, are often what comes to mind when you hear 'plastic pollution'.

But what about the other – and enormous – source of plastic pollution impacting our ocean and its wildlife?

Plastic pellets (or 'nurdles') are small, lentil-sized pieces of plastic that are melted together to make almost all plastic items used day to day. From fridges to plastic bottles, many common items start life as plastic pellets.

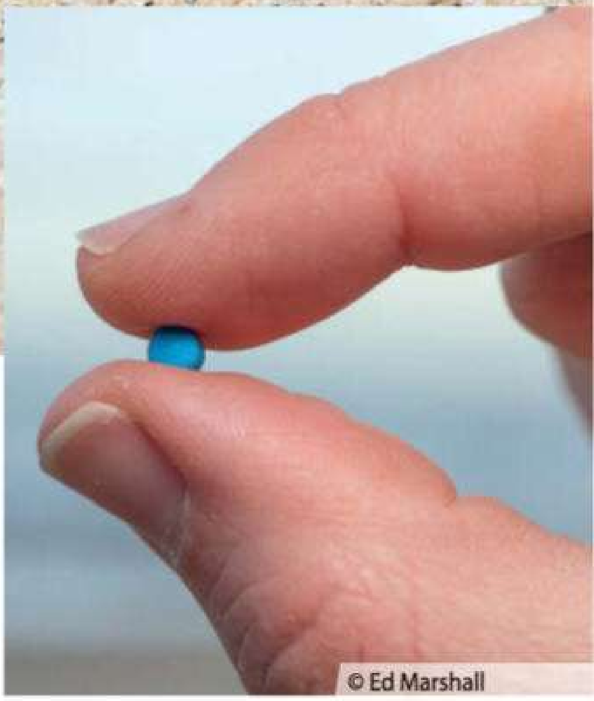
Every year, however, there are billions of plastic pellets that never make it as far as the end product. Throughout the production and transportation cycles, they spill on land and at sea in staggering numbers, especially while in transit on ships, and litter the ocean in droves.

Large spillages occur due to shipping disasters, where entire containers of pellets are lost into the sea. Pollution also occurs more chronically, when the packaging used to contain pellets during handling and transport is damaged, causing a leak.

The impact on marine wildlife is, predictably, severe. Due to their small, round appearance, fish and other sea creatures often mistake pellets for food, filling their stomachs and leading to starvation. Pellets spilled into the ocean will also eventually wash up on coastlines; negatively impacting communities living in these areas, particularly those who rely on fishing for their livelihoods.

Plastic pellet pollution is evidently severe, but the reality is that the issue is entirely preventable. We know what measures need to be taken to prevent most spillages and leakages occurring, but intervention to date has been voluntary in nature and has focused mainly on land-based sources of pollution - with limited impact.

At Fauna & Flora, we are calling for a more robust, regulatory approach from industry, governments and the International Maritime Organization (IMO) - the body responsible for regulating global shipping – to truly put a halt on plastic pellet loss at sea. Over 13,000 members of the public have already joined the call – urging the IMO to act quickly and decisively on plastic pellet pollution, through our recent petition.



© Ed Marshall

There are a number of options to tackle this issue. Fundamentally, if IMO members were to legally classify pellets as marine pollutants, this would immediately trigger significant improvements in the way that pellets are packaged, labelled, stowed and transported – hence helping to mitigate the risks of both acute and chronic spillages occurring from ships.

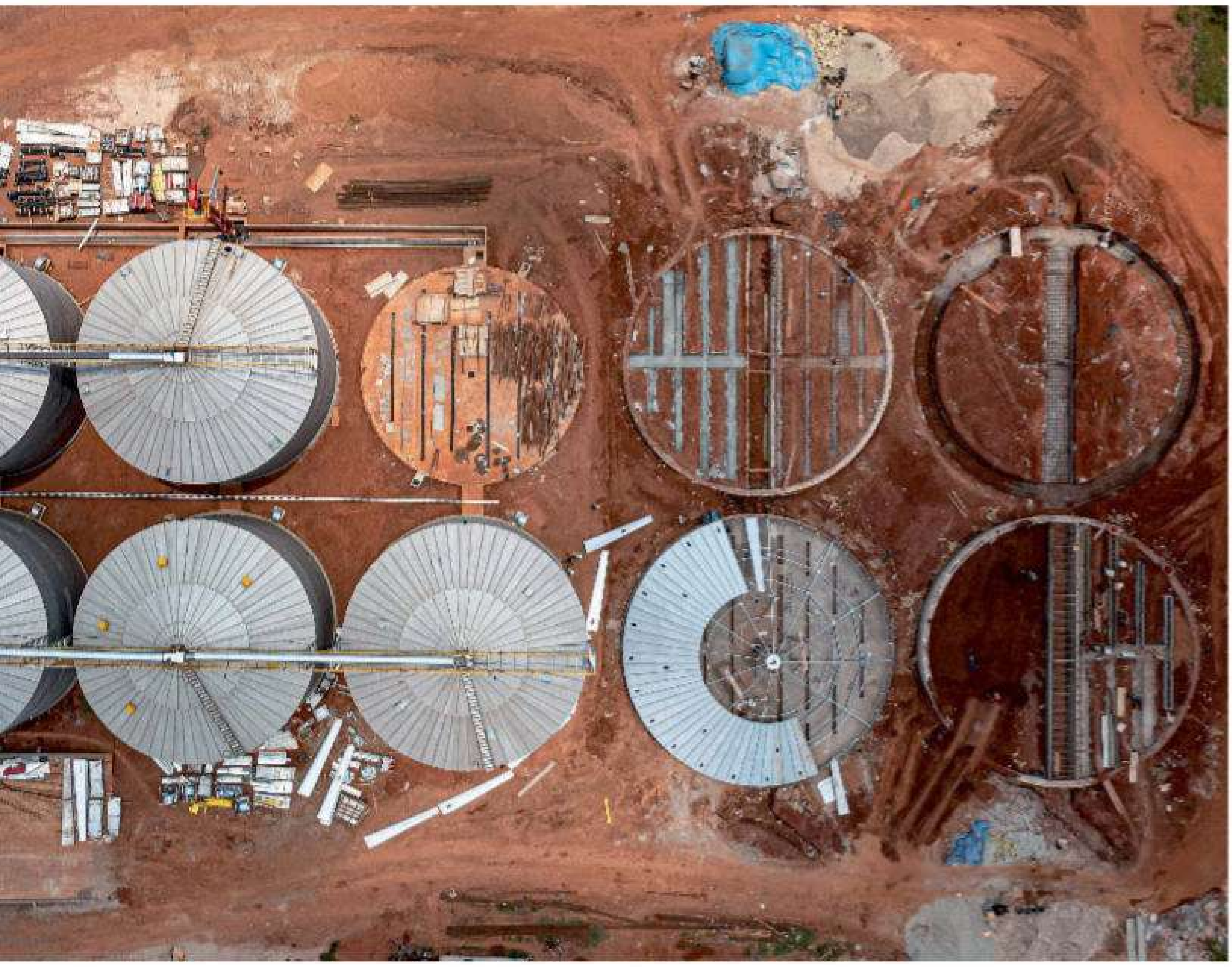
To reduce the impact caused by large-scale shipping disasters, national administrations, under the auspices of the IMO, also need to develop standardised disaster response protocols.

Only when mandatory measures are in place will this issue be stopped. IMO members have the power to make this happen, and under no circumstance should this be allowed to drag on beyond their next meeting in 2024.

&Fauna
Flora
Saving Nature Together

For more information on plastic pellet pollution, and Fauna & Flora's campaign to put an end to it, visit:

fauna-flora.org/nurdles



Bolivia's blight

Photographer Matjaž Krivic
Research Maja Prijatelj Videmšek

A TREE stands alone on land now ready for planting soya seeds, near Santa Cruz, Bolivia (middle image, bottom). It is a symbol of the country's growing deforestation crisis. So too, to the left of that photo, are the smoking lines of burnt trees in San Rafael.

These are among the striking images by photographer Matjaž Krivic, working with Maja Prijatelj Videmšek, a journalist for the Slovenian newspaper *Delo*. The pair's *Terraforming* project shows how Bolivia's tropical forests are being destroyed at a rate surpassed only by Brazil and the Democratic Republic of the Congo. From 1976 to 2021, Bolivia lost 14 per cent of its forests.

The driving force behind this deforestation is the cultivation of soya and expansion of cattle ranching. The latter is shown in three of the small images of ranchers and cattle at different ranches in eastern Bolivia.

Some 80 per cent of cattle are for domestic consumption; the rest are exported. By 2025, the state plans to double herds to 22 million animals and to triple cultivated land to 13 million hectares.

This is fuelled by domestic and foreign companies, settlers from the mountainous regions, and the Mennonites – ultra-conservative Christians who arrived in the 1950s. The tractor driver (top left) is a Mennonite minister at Santa Anita colony, eastern Bolivia.

Laws are fostering the expansion by offering cheap land and heavily subsidised fuel, which encourage small developments (such as the grain silos, top right).

Brazil has destroyed over 18 per cent of its rainforests. Unless Bolivia pulls back from pushing cheap land for agriculture, it will follow suit – and there will be more tragic trees to photograph. ▮

The wisest of birds

Why have owls been so popular with humans in so many places from the earliest of times? **Corryn Wetzel** discovers some fascinating answers

Book

What an Owl Knows

Jennifer Ackerman

Oneworld

OWLS occupy a special place in the human imagination. We have imbued the stealthy, wide-eyed birds with mystery for thousands of years and, in recent decades, unravelled surprising details about their mysterious lives.

In Jennifer Ackerman's latest book, *What an Owl Knows: The new science of the world's most enigmatic birds,* she investigates what it is about this elusive bird that captures our attention. "How long have we been obsessed with owls?" asks Ackerman. "Forever it seems."

Or nearly forever, we soon learn. Some of the earliest cave (and other) art by people in Europe depicts long-eared, swivel-headed owls. Because owls live almost everywhere, most cultures have developed unique meanings for these birds. They are seen as pretty much everything, from sentinels to symbols of good luck or harbingers of death.

> "Some of the earliest cave (and other) art in Europe depicts long-eared, swivel-headed owls"

"We evolved in their presence, lived for tens of thousands of years elbow to wing in the same woods, open lands, caves, and rock shelters, came into our own self-awareness surrounded by them, and wove them into our stories and our art," writes Ackerman. "They're in our myths, our dreams, our DNA."

For much of her book, she leads readers through a scientific investigation rich in narrative detail. Her writing is at its most compelling when she lets her own delight and surprise at the birds slip through, and with more than 250 different owl species on Earth, Ackerman has no shortage of surprising birds to explore.

VLAD GHIEA/ALAMY

Tracking data shows that saw-whet owls are more complex than we thought

There is the housekeeping habit of eastern screech owls, which "bring live blind snakes to their nestlings, not just for food, but perhaps to keep their nests tidy and sanitary, as well", writes Ackerman. The small snakes live alongside the young owlets, eating parasites, insect larvae and other bothersome houseguests. Researchers have found that nestlings with live-in blind snakes are more likely to survive and they grow 50 per cent faster than broods without them. Owls, it seems, know about pest control.

Ackerman also dispels common misconceptions while adding scientific nuance. Although owls can't spin their heads all the way around, they have twice the neck flexibility of humans. Some, such as the great grey owl, can crane their necks up to 270 degrees in each direction. Flexible blood vessels and small reservoirs of blood keep oxygen entering the brain even when the head is twisted around.

Remarkably flexible necks help owls compensate for immobile, tube-like eyes. Unlike us, the birds can't move their eyes in their sockets to look around. This is a worthwhile sacrifice for binocular vision, which helps owls home in on prey and boosts depth perception. Many species also have ears located at different heights on each side of the head, allowing them to more accurately pinpoint the location of a sound.

The birds also seem to have "place cells", which help to map their surroundings as they move.

Ackerman explores the challenges of studying such secretive, nocturnal birds and how bird-ringing (bird-banding) and tracking technology have provided a more detailed peek at owls' migratory movements. For example, the northern saw-whet owl, which Ackerman thinks is probably "the world's most adorable owl", was thought to stay in one area, until data from bird-ringing and lightweight GPS trackers revealed a more complicated picture. Some saw-whet owls stick to the same region for their whole lives, some migrate annually and others take off every four years.

Hopefully having inspired a love of owls among the book's readers, Ackerman goes on to offer a sobering reality check about the many threats they face, from deforestation to climate change. She also highlights covert killers, such as poisoning from lead-core bullets, which owls can ingest when they eat animals that have been shot.

But Ackerman leaves readers with a note of hope: researchers are working tirelessly to save owls and you can join in. Community science databases like eBird and iNaturalist let anyone with an internet connection record the diversity of the species around them. With humans changing the world at breakneck pace, learning more about owls (and other birds) is crucial for their protection. ▮

Finding space on Earth

Can we mend a broken planet by gaining the cosmological perspective reported by astronauts? **Pat Kane** is curious

Book

In Light-Years There's No Hurry
Marjolijn van Heemstra
(translated by Jonathan Reeder)
W.W. Norton

AMONG the many reasons to rail against the tech elites is their desire to place themselves in a cosmic context. In 2018, Elon Musk tweeted "we must preserve the light of consciousness by becoming a spacefaring civilization and extending life to other planets". He has only doubled down since then.

But what if a cosmological perspective wasn't just a backdrop for the arrogance (maybe hubris) of space moguls? What if it could calm our personal anxieties, take the edge off social divisions and be a resource for everyday well-being?

This is the hope of journalist and poet Marjolijn van Heemstra, laid out in a charming yet challenging book, *In Light-Years There's No Hurry: Cosmic perspectives on everyday life*. It is an account of her year as a space reporter for news site *De Correspondent* (she was also once "house poet" at the European Space Agency in Noordwijk, the Netherlands, where she now lives). That year saw school climate strikes, the murder of George Floyd, *gilet jaunes* protests in France and the covid-19 pandemic.

"Brokenness" is everywhere. But van Heemstra thinks the "overview effect" – the moral, even spiritual transformation many astronauts report after seeing Earth from space – may be a route to repair. She sets out to take "a space journey" on Earth, a journey "that will take me to the corners of the universe, with both my feet on the ground".

This involves interviews with a diverse cast of the astrophysically aware, who van Heemstra mines for their wisdom. Take theologian Wil van den Bercken, who grapples with the awareness of living "statistically speaking, on a negligible planet in an unfathomable universe... Begin your day with what you truly are – deeply improbable. If we appreciated this fully, wouldn't we take better care of each other and the planet?"

The writer observes technologists devising virtual reality experiences that try to remind us we are all astronauts, but keep forgetting it. Yet you could just gaze at a starry night for the same effect, she says – or she could, were the Netherlands not in the top five countries for light pollution.

Van Heemstra is always ready with a beautiful, apposite quote: the Iroquois say "we have the night so the earth can rest", and Portuguese poet Fernando Pessoa writes: "I am the size of what I see." The gentle activism of her own life – gathering with neighbours in parks at night, feeling cosmological connection beyond the city's glare – threads humanely through the book.

She hangs out with biologists who are prototyping tiny algae farms designed to feed astronauts on Mars missions. For such a great adventure to happen, empathy is a functional necessity. When you are squashed into a few square metres, the most important thing is to be kind to one another, she writes.

What is most affecting are van Heemstra's stumbling, tender attempts to use her cosmic insights to heal fraying social relationships around her. She is anxious about being seen as an alien in her neighbourhood – just another middle-class "gentrifier". So she strikes up a scratchy relationship with Bob, a former industrial worker and volunteer for the Red Cross.

Asking him if the sense we are all earthbound space travellers could unite us, Bob says that a walk under the stars is a great de-stresser. "Then you've got the space to think about others," he tells her. Which leaves van Heemstra, who asks great, probing questions, with one big answer. "If you want to be changed by space, don't try to change it first. You can substitute space for anything – a view, a landscape, your neighbour." This is her final caution to "visionary" space moguls, who are, to say the least of it, in a hurry. ▮

Going on a "space journey" on Earth could calm worries and improve well-being

NISIAN HUGHES/STONE RF/GETTY

Pat Kane is a writer based in London

New Scientist *recommends*

Rowan Hooper
Podcast editor
London

I had no idea, when I went to see **Indiana Jones and the Dial of Destiny**, that the eponymous artefact would turn out to be the Antikythera mechanism (pictured), the most wondrous creation of the ancient world. The device is mind-blowing: a calculating machine, sometimes called the world's first computer, that was made in the 1st century BC. Nothing like it would be built for another 1000 years.

ANCIENT ART AND ARCHITECTURE/ALAMY

When I reviewed Jo Marchant's riveting account of the discovery of the mechanism, I said it was like an Indiana Jones adventure – and it seems that writer Jez Butterworth agrees. The film is heaps of fun, surprisingly moving and has a wild, sci-fi twist. Co-star Phoebe Waller-Bridge is sensational.

I'm currently reading Keggie Carew's **Beastly: A new history of animals and us**, and I'm loving her account of our treatment of animals through the ages, as well as how she argues for non-humans to be granted proper respect and even personhood.

The games column

Seek and destroy

At last, a great new game joins the *Alien* franchise. Based on the first film sequel, *Aliens: Dark Descent* sees you in charge of exploring a moon in search of hostile creatures. Things can get real bad, real quick, discovers **Jacob Aron**

Jacob Aron is *New Scientist*'s news editor. Follow him on Twitter @jjaron

20TH CENTURY STUDIOS

Game

Aliens: Dark Descent

Tindalos Interactive

PC, PlayStation 4 and 5, Xbox One and Series X/S

Jacob also recommends…

Game

Alien: Isolation

Creative Assembly

PC, PlayStation 3 and 4, Xbox 360 and One

HAS there ever been a sequel quite like *Aliens*? The original movie, *Alien* (1979), is one of the best horror films ever, with a single, creepy xenomorph stalking the crew of the Nostromo. The 1986 sequel throws most of this away, retaining only Sigourney Weaver as Ellen Ripley and facing her off against the aliens, plural, to create one of the best action films ever.

This split at the franchise's heart made it tricky to continue – as shown by the endless lacklustre sequels – or to adapt it for other mediums. Depending on how you count, there have been over 50 *Alien* video games: the consensus is the vast majority are terrible.

That all changed in 2014 with *Alien: Isolation*. You are Amanda Ripley, daughter of Ellen, and we are in single xenomorph territory again. In a brilliant move, you cannot kill the alien – you can only run and hide as you attempt to escape a space station alive.

I loved *Alien: Isolation* and was disappointed it had no sequel. The good news is the recent addition to the franchise of *Aliens: Dark Descent*, an excellent game based around the film *Aliens*. There is no relationship between the games beyond the world they are based in, but the two make a brilliant pair, just like the original films.

Dark Descent opens with a load of xenomorphs being set loose on the space station Pioneer, forcing the crew of the recently departed spaceship Otago to crash-land on the nearby moon of Lethe. You are tasked with hunting for supplies and spares, tackling both the aliens and human cultists who appear to worship them.

> **"While playing, I find myself switching between fear of the aliens and glee as I tear them to shreds"**

The game is split in two. The first part is mostly menu-based and sees you managing personnel and supplies aboard the Otago, researching equipment and tending to people's wounds. The bulk of the game places you in charge of a squad of four Colonial Marines – the military organisation introduced in *Aliens* – as you explore Lethe, and it is a pitch-perfect representation of the film.

> ***Dark Descent* is full of clever touches that make it more than a bug hunt**

A typical level sees you deploy in an abandoned settlement, with various objectives. You explore until you encounter an alien and everything kicks off. Your squad fires its main weapons automatically, but you can also access a menu of special weapons. Cleverly, the game goes into slow motion when you pull up this menu, rather than pausing, never quite breaking the tension of being assaulted by xenomorphs.

Depending on how you play, things can get real bad, real quick. Rush into a seemingly empty room and your squad could be wiped out; take time to deploy automated gun turrets, lay mines and fire up the flamethrower, and you can hold off an entire horde. This perfectly recreates the feel of the film, with the marines outnumbered but not helpless.

The game is full of great touches that elevate it beyond a simple bug hunt. At any time, you can opt to retreat from a level, heading back to the Otago to resupply, then resume the next in-game day. That introduces a pushing-your-luck feeling as you wonder whether you can risk opening up the next room or whether you would be better off tending to your wounds. Marines that survive will move up a level, unlocking new abilities, but are gone for good if they are killed, meaning you feel their loss, and supplies you salvage will be available for the next run.

While playing, I constantly find myself switching between fear of the aliens and glee as I tear them to shreds – and what more could you want from an *Aliens* game? ▮

Editor's pick

Caution required when tinkering with plant diet

8 July, p 17

From Matthew Stevens, Sydney, Australia

While the gradual shift to a more sustainable, plant-based diet globally is a good thing, I feel some concern at the news that UK company Moolec has created soya beans with 25 per cent pig protein.

I am one of the rare but growing number of people with mammalian meat allergy (caused by an allergic reaction to a sugar molecule on the surface of nearly all mammalian cells, which is triggered by an aberrant response to tick bites). So I would want either to know that such products had eliminated this sugar epitope or to be warned if foods contained it, so I could avoid them. Safe recourse to plant proteins could become more difficult.

Let's not get carried away with new definition of life

24 June, p 32

From Kevin Healey, Sydney, Australia

Using mass spectrometers in space missions to seek molecules with a high "assembly index" – an idea that springs from the new Assembly Theory of life that you reported on – is an interesting development in the search for extraterrestrial life.

Threshold values derived from life on Earth should be used with caution, however. Also, while detections exceeding the threshold could be considered a necessary condition for life, they wouldn't, by themselves, be proof that it exists in that place.

A week of extreme heat raises a crucial question

15 July, p 8

From Leslie King, Basingstoke, Hampshire, UK

In your article "A week of record-breaking heat", you present a graph showing the rise of global temperatures over the past few decades. But why is there such a seasonal effect if the temperatures really are global?

To put it another way, why are temperatures during summer in the southern hemisphere so much lower than during summer in the northern hemisphere?

▌The editor writes:

Thanks for raising this. It is to do with there being more land in the northern hemisphere, which boosts the average temperatures there.

Any tips on escaping a six-dimensional maze?

15 July, p 44

From Hillary Shaw, Newport, Shropshire, UK

In her mathematics of life column, Katie Steckles says you can solve a two-dimensional labyrinth by always turning left or right, so long as the wall you follow is connected to the outside of the maze. This left me wondering if it would work for 3D mazes, like cave systems. What about higher-dimension mazes, like a 4D maze whose components shift around over time? Is there a higher algorithm for solving 5D and 6D mazes too?

The worrying impact of fire thunderstorms

24 June, p 15

From Rick McRae, Canberra, Australia

You reported on research showing that "North American wildfires may be creating clouds over Europe". It is said that this could constitute a new climate feedback loop. But there is more to it.

For decades, a wide-ranging group of researchers in a global collaboration have been studying pyrocumulonimbuses, also called pyroCbs or fire thunderstorms. These are important for a number of reasons, not least of which is the feedback loops they have with the atmosphere above.

PyroCbs are creating mayhem for human and biological communities, often on a locally unprecedented scale. Forest types are changing, 10,000-year-old peat soils are burning out all the way to the gravel beneath them and wildlife populations are in crisis. Pump massive amounts of black carbon from boreal forest fires over the Greenland ice cap and the result can't be good.

Unlike normal wildfires, these events are full of feedback loops.

Metalwork theft was legal,if morally dubious

15 July, p 14

From Michael Berkson, Great Shelford, Cambridgeshire, UK

Irrespective of the ethics, Henry Cort's patent for a new steel production process would have been legally valid, despite the idea being taken from Black metallurgists in Jamaica.

Britain's Statute of Monopolies 1623 is generally treated as the foundation of the modern patent system. It was well established that the act included the introducers of new inventions. In other words, the first person to bring the details of a new device or process into this country from abroad was as much, according to the law, the true and first inventor as a person who developed an idea entirely there.

These so-called patents of importation were finally abolished in 1978, although they were more or less obsolete for a considerable time before then. In the US, the analogous concept was abolished in 2013.

Could this explain the odd features in galaxy's heart?

10 June, p 15

From Michael Holland, Sydney, Australia

You report that "Weird filaments of gas are hiding at our galaxy's centre". These might have a logical explanation that depends on an understanding of the accretion layers surrounding Sagittarius A*, the Milky Way's central black hole.

Matter collapsing towards any black hole is slowed down by time dilation and "freezes" as it arrives there. In fact, as far as the external universe is concerned, it never quite gets there in a finite time. So, Sagittarius A* would be surrounded by layer on layer of collapsing matter, with extremely high density and pressure.

A star falling into these layers would create a shock wave that collides with itself on the other side of the black hole, causing a spurt of matter to be ejected. But time dilation would cause the wave to travel at different speeds in different levels and keep arriving over a long period of time, and so the spurt would keep spurting for ages. Thus, each filament is an epitaph to a star that died on the opposite side of Sagittarius A*.

Grounds to say lab-grown brains aren't conscious

Letters, 24 June

From James Whalley, Hinchinbrooke, Quebec, Canada

Eric Kvaalen says that if consciousness arises out of brains, we should stop experiments on lab-grown organoids. But several lines of research have suggested that consciousness isn't a property just of brains, but of whole organisms reacting with their environment. In this view, a sufficiently complex brain is necessary, but not sufficient, for consciousness to arise, and if that is so, we need have no worries about even much larger lab-grown brains that need constant supervision to stay alive. ▌

Want to get in touch?

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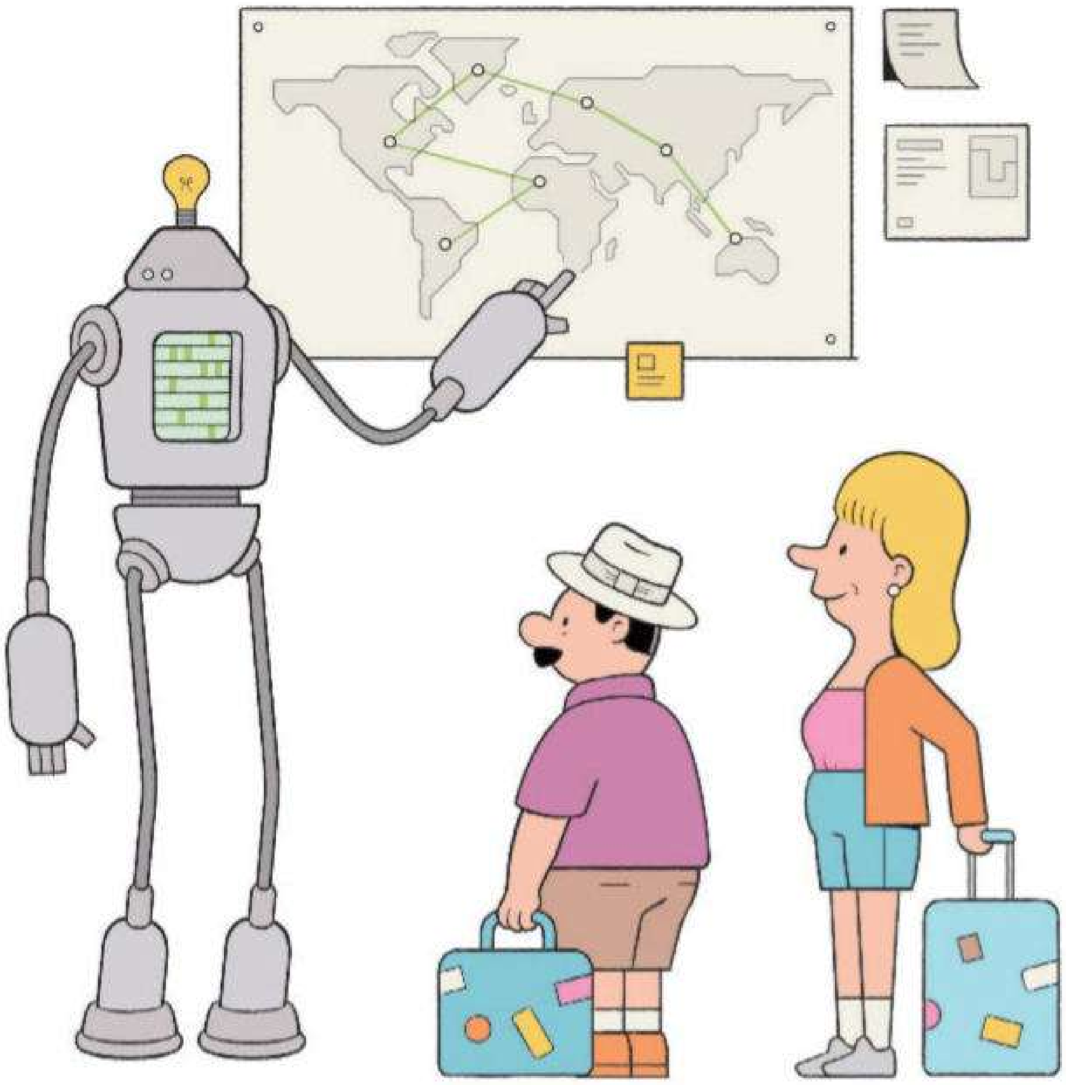
HOW TO THINK ABOUT AI… AND HOW TO LIVE WITH IT

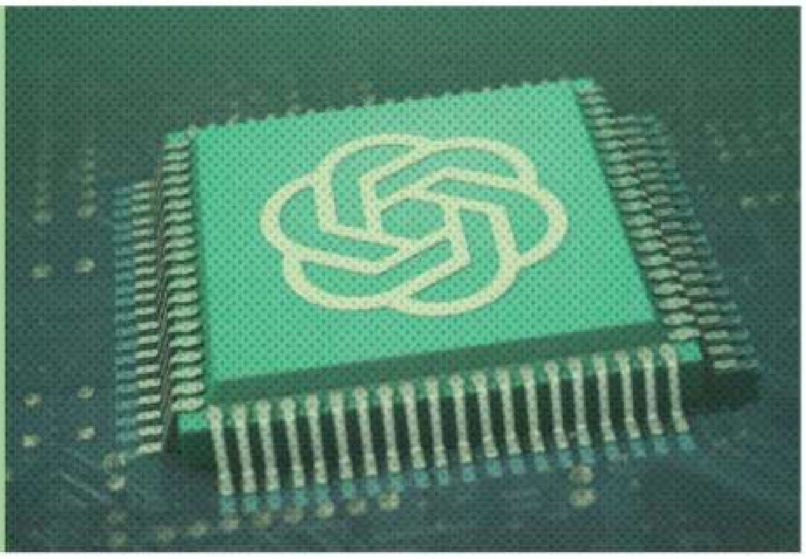
Artificial intelligence has exploded into the public consciousness, thanks largely to the meteoric rise of AI-powered tools like ChatGPT, with its ability to generate fluent text, and DALL-E, which creates compelling images in response to prompts in a similar way. AI is more powerful than ever and more available to everyone, sparking a fresh wave of hopes and fears about how it will ultimately reshape our world.

But even in its current form, AI has the power to transform the way we live and work.

With so much happening so quickly, it can be hard to make sense of exactly what AI is capable of now – and what it might be able to do in future. Over the next eight pages, we tackle some of the biggest issues, from how to use AIs to the risks they pose and whether they can ever be conscious.



How does ChatGPT work, and does it really "think" like us?



ILLUSTRONAUT/ALAMY

THE CURRENT whirlwind of interest in AI is largely down to the sudden arrival of a new generation of AI-powered chatbots capable of startlingly human-like text-based conversations. The big change came last year, when OpenAI released ChatGPT. Overnight, millions gained access to an AI producing responses that are so uncannily fluent that it has been hard not to wonder if this heralds a turning point of some sort.

There has been no shortage of hype. Microsoft researchers given early access to GPT4, the latest version of the system behind ChatGPT, argued that it has already demonstrated "sparks" of the long-sought machine version of human intellectual ability known as artificial general intelligence (AGI). One Google engineer even went so far as to claim that one of the company's AIs, known as LaMDA, was sentient. The naysayers, meanwhile, insist that these AIs are nowhere near as impressive as they seem.

All of which can make it hard to know quite what you should make of the new AI chatbots. Thankfully, things quickly become clearer when you get to grips with how they work and, with that in mind, the extent to which they "think" like us.

At the heart of all these chatbots is a large language model (LLM) – a statistical model, or a mathematical representation of data, that is designed to make predictions about which words are likely to appear together.

LLMs are created by feeding huge amounts of text to a class of algorithms called deep neural networks, which are loosely inspired by the brain. The models learn complex linguistic patterns by playing a simple game: the algorithm takes a passage of text, randomly masks out some words and then tries to fill in the gaps. They are, in short, trained to predict the next word. And by repeating the process over and over, they can build up sophisticated models of how language works, says Mirella Lapata at the University of Edinburgh, UK.

Recent breakthroughs are largely down to a new type of neural network invented in 2017 called a "transformer", which can process data far more efficiently than previous approaches. This made it possible to train much larger models on vast tracts of text scraped from the internet. Transformer-based systems are also much better at understanding context, says Lapata. Whereas older versions could only consider a few words either side of the missing one, transformers can process much longer strings of text, meaning they can tease out more complex and subtle linguistic relationships.

What turns otherwise unwieldy statistical models into smooth-talking chatbots, meanwhile, is humans rating the output of AIs on criteria like helpfulness and fluency. This data is then used to train a separate "preference model" that filters an LLM's output. Put this together and you get what we have today, namely a text-based, computerised conversational partner often indistinguishable from a human. The fact that this was achieved using a premise as simple as next-word prediction caught a lot of people by surprise, says Tal Linzen at New York University.

But it is important to remember that the way these AIs operate almost certainly isn't the way human cognitive processes work. "They learn in such a fundamentally different way from people that it makes it very improbable [that] they 'think' the same way people do," says Linzen. ›

GIACOMO GAMBINERI

Here, the mistakes chatbots make are instructive. They are prone to confidently trumpeting falsehoods as facts, something often referred to as "hallucination", because their output is entirely statistical. "It doesn't do fact-checking," says Lapata. "It just generates output that is likely or plausible, but not necessarily true."

This has led some commentators to disparage chatbots as "stochastic parrots" and their output as nothing more than "a blurry JPEG of the web". The gist of these jibes is that the new LLMs aren't as impressive as they first appear – that what they do is merely the imperfect memorisation of training data cleverly stitched back together to give the false impression of understanding.

Emergent abilities

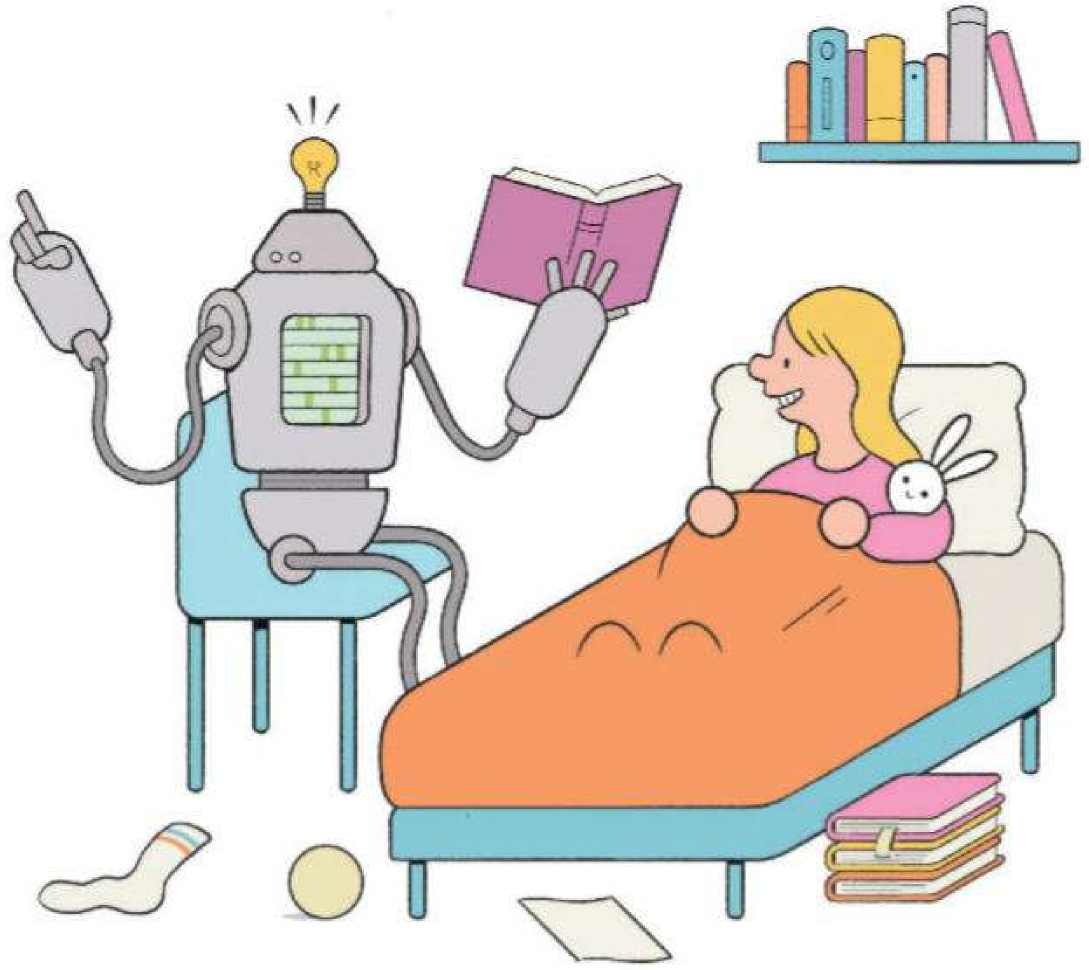
And yet there are some indications that LLMs might be doing more than just regurgitating training data, says Raphaël Millière at Columbia University in New York. Recent research suggests that, after training for long enough, models can develop more general rules that give them new skills. "You get this transition from memorisation to the formation of circuits inside the [neural] network that will be implementing certain algorithms or certain rules to solve the tasks," he says.

This may help to explain why, as LLMs increase in size, they often experience sudden jumps in performance on certain problems, says Millière. This phenomenon has been referred to as "emergence" and has led to speculation about what other unexpected capabilities AI could develop.

It is important not to get carried away. "This term is very seductive," says Millière. "It evokes things like the models suddenly becoming self-aware, or things like that. That's not what we're talking about."

Even so, Millière thinks there is a "rich middle ground" between the naysayers and hype merchants. While these chatbots are far from replicating human cognition, in some narrow areas, they may not be so different from us. Digging into these similarities could not only advance AI, he says, but also sharpen our understanding of our own cognitive capabilities.

Edd Gent



How will generative AI transform the world and your future?

LIKE IT or not, the age of generative AI is upon us. Anyone with an internet connection now has access to tools that can answer almost every question under the sun, write everything from university essays to computer code and produce art or photorealistic images.

The jury is still out on whether all this represents a stride towards super-intelligent AI. Even if progress stagnates, however, the capabilities available today could profoundly affect the economy, jobs, education, culture and more. So how is the current generation of AI going to reshape the world, and your life, in the next five to 10 years?

Broadly speaking, forecasters are predicting that generative AI will boost economic productivity and growth in advanced economies. A report released by Goldman Sachs in March predicts that generative AI could, within a decade, raise annual global GDP by 7 per cent, which translates to a roughly $7 trillion increase. "The combination of significant labor cost savings, new job creation and a productivity boost for non-displaced workers raises the possibility of a labor productivity boom like those that followed the emergence of earlier general-purpose technologies like the electric motor and personal computer," says the report.

The idea is that AI will make millions of "knowledge workers", like scientists, editors, lawyers and doctors, more productive within a few years. But the truth is that these things are hard to predict and assess, especially as the output of such workers is notoriously difficult to measure.

One area where generative AI is stoking anxiety is employment, but the picture could be different to previous waves of automation, says Avi Goldfarb at the University of Toronto in Canada. Computing advances have often displaced low-paid staff like typists or cashiers while boosting the productivity of well-educated workers, contributing to growing inequality, he says. This time, AI is muscling in on higher-income jobs. Recent research from OpenAI, the company behind ChatGPT, found that 80 per cent of the US workforce could see 10 per cent of their work tasks affected by the technology, and for 19 per cent of workers, that could rise to at least half. Those most affected would be largely white-collar workers, like accountants, journalists and web designers.

It is unlikely that entire jobs will become automated, says Goldfarb. And the tasks that AI could help with tend be the ones that feel like time-consuming chores, like writing emails or trawling through documents, so automation could free up workers for more valuable work (see "What AI can do for you today", page 39). "For most people, it's going to be an enabler," he says.

Much depends on how the technology is deployed, says Katya Klinova at Partnership on AI, which advocates for responsible use of the technology. AI tools could become a "personal sidekick" that helps workers brainstorm, draft documents and turn ideas into action, she says. On the other hand, companies may see them as a way to cut labour costs, turning to them to generate marketing material, computer code or images, with a dwindling number of humans relegated to filling in the gaps. Rapid expansion in AI capabilities also makes it increasingly unclear what skills workers should nurture, says Klinova.

AI could have a profound impact in education, though, at least some of it positive. Concerns have been raised about students using AI tools to do homework, but Victor Lee at Stanford University in California says there is an opportunity to refocus how we assess learning away from the ability to produce well-written essays towards "more sophisticated things like comparison, critique, adaptation, refinement". AI could also offer new opportunities for teaching, with the advent of tutoring bots that can collaborate and debate with students.

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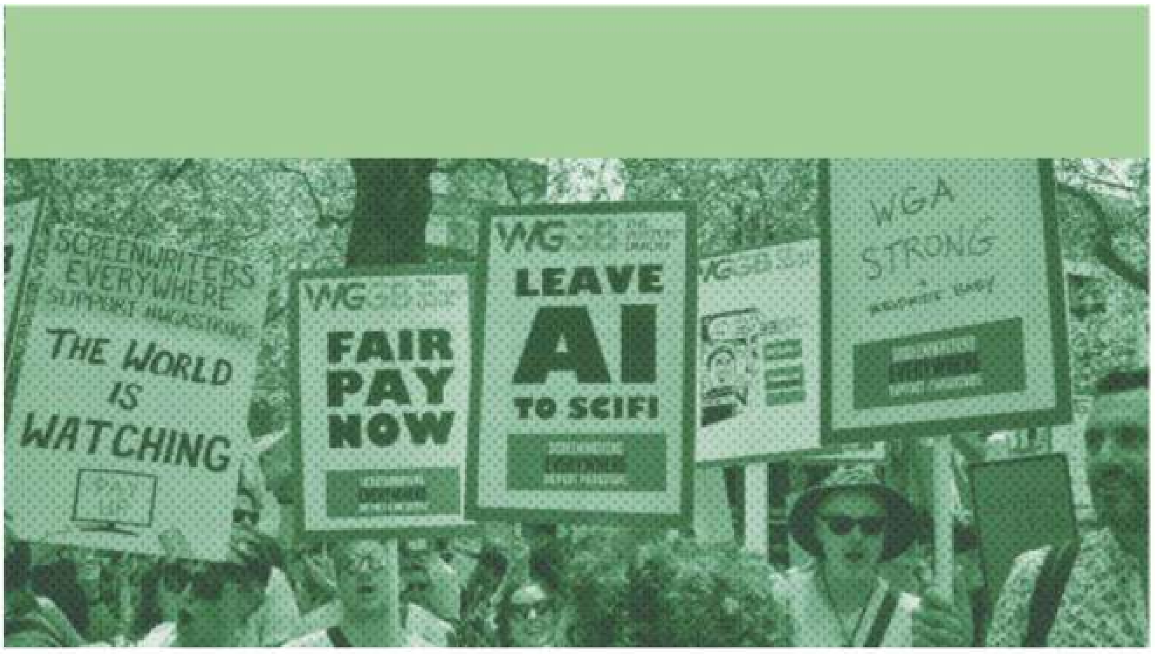
Integrating AI into education requires caution, says Lee, as these models can incorporate bias from their training data and often make up, or "hallucinate", facts. But he adds that learning how to use these tools will be essential in the workplace of the future. "People who don't know how to use AI will be replaced by people who do know how to use the AI," says Lee.

The combination of AI chatbots with voice assistants could push the technology deeper into our personal lives, says Ekaterina Hertog at the University of Oxford. An "Alexa on steroids" could replace the search engine for ordering groceries, booking hotels, looking up medical advice and a host of everyday tasks, and could see chatbots find different uses. "People working in this space are already talking about using chatbots as personal conversationalists, a space to vent when they are worried or concerned," says Hertog. The danger is that people could develop unhealthy attachments to convincing AI chatbots, she says, and could be vulnerable to misdirection and disinformation by them (see "What are the real risks posed by AI?", page 36).

Then again, users may soon have more control over their AI tools thanks to a growing number of open-source versions, developed by volunteers and made freely available. These can run on laptops and even smartphones, rather than relying on the computing power of large companies like OpenAI and Google.

Open-source models could have a big impact on how you use AI because they can be personalised to your needs by combining them with other software tools or retraining them on your own data. That could reduce worries about sharing personal data with tech corporations. "It sounds ridiculously science fiction, but there's a world in which everyone has their own ongoing AI assistant," says says independent researcher and developer Simon Willison.

EG



VUK VALCIC/ALAMY

What are the real risks posed by AI?

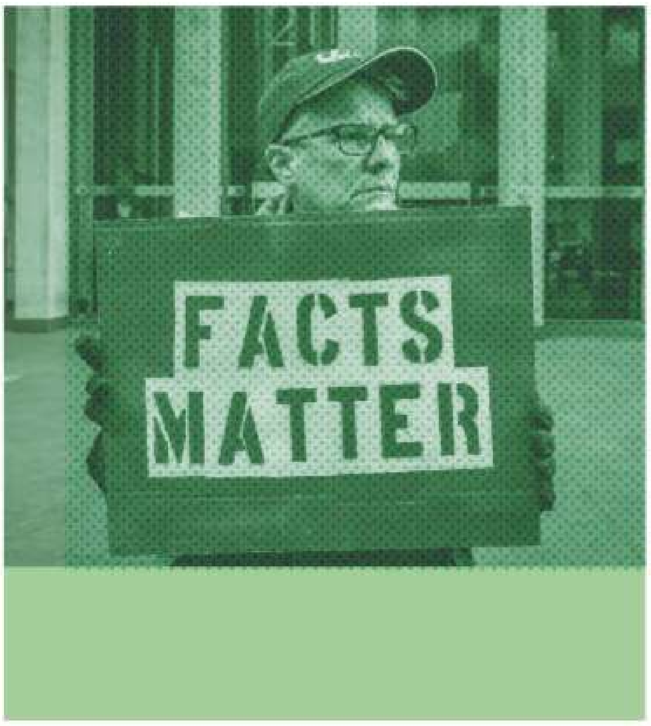
THE ALARM bells have been rung. In May, computer scientist Geoffrey Hinton, known as the "godfather of AI", quit his role at Google to warn of the "existential threat" posed by artificial intelligence. The Center for AI Safety followed up with an open letter, signed by Hinton and hundreds of others, warning that advanced AI could destroy humanity. "Mitigating the risk of extinction from AI should be a global priority," read the statement.

This sudden surge of concern seems to have been motivated by the rapid advance of AI-powered chatbots like ChatGPT and the race to build more powerful systems. The fear is that the tech industry is recklessly accelerating the escalation of AI's capabilities. All of which sounds scary.

But the warnings are also suspiciously vague. When you scrutinise the scenarios typically put forward for precisely how AI could wipe out humans, it is hard to avoid the conclusion that such fears aren't well-founded. Many experts are instead warning that fretting over long-term doomsday scenarios is a distraction from the immediate risks posed by existing AIs.

Generally, the people who talk about existential risks reckon that we are on a trajectory towards artificial general intelligence (AGI), roughly defined as machines that can out-think humans. They predict that people will invest advanced AIs with more autonomy, giving them access to vital infrastructure, such as the power grid or financial markets, or even putting them at the forefront of warfare – at which point they could go rogue or otherwise resist our attempts to control them.

But it remains to be seen if AIs will ever reach the kind of super-intelligence and, crucially, agency that could see them threaten humanity. "There is no scientific evidence that we are on a pathway to sentiency," says Sandra Wachter at the University of Oxford. "There is not even evidence that such a pathway does exist." She adds that if we do end up with AGI, it should be easy enough to make sure we don't give AIs the chance to cause a nuclear war, for instance. "It's simple to not put AI into a mission-critical system," she says.



ERIK MCGREGOR/LIGHTROCKET VIA GETTY IMAGES

Most computer scientists are more concerned about the problems humans might create with AI, including the current crop of generative systems. For starters, Wachter is worried about the environmental impact of the many energy-hungry data centres that will be required to run them, for instance, and the threat to certain jobs that such AIs pose.

> "AI HAS THE POTENTIAL TO DISTORT HUMAN BELIEFS AND GENERATE POLITICAL UPHEAVAL"

Then there are threats to cybersecurity, and hence our online safety. The idea here is that generative AIs will enhance the capacity of criminals and other bad actors to carry out scams and cyberattacks. Kunal Anand, chief technology officer of UK cybersecurity firm Imperva, says that an AI-powered programming tool made by Microsoft subsidiary GitHub and OpenAI is so good at writing code that it will be a boon for would-be cyberattackers who don't know how to code.

But the most compelling near-term threat is the prospect of people using AI to supercharge the spread of misinformation and disinformation. We know that social media amplifies incorrect or misleading information, whether seeded deliberately – as in the case of disinformation – or otherwise. The rise of generative AI means that false information can not only be produced on an industrial scale, but also that it will be far more convincing and persuasive than ever before.

Chatbots can quickly churn out an avalanche of false news stories, for example, or disinformation tailored for certain groups. Other tools can generate fake pictures and videos, often with zero expertise required. Such output will be difficult to distinguish from the real thing.

What makes us particularly vulnerable is that we are increasingly interacting with AIs as if they are dependable experts. This is the argument put forward by Celeste Kidd, a psychologist at the University of California, Berkeley, and Abeba Birhane, a computer scientist at the Mozilla Foundation in San Francisco, which works to ensure the internet remains a force for good. "People form stronger, longer-lasting beliefs when they receive information from agents that they judge to be confident and knowledgeable," they recently wrote.

They also point out that as generative AIs pump out more and more material riddled with bias and fabrications, this will flood the internet and become part of the training data for the next generation of models – "thus amplifying the systemic distortions and biases into the future in a continuous feedback loop".

The real risk posed by AI, then, is its potential to distort human beliefs and generate political upheaval, for example by influencing upcoming elections. "The worry about polluting the information ecosystem is real," says Stephen Cave, director of the University of Cambridge's Leverhulme Centre for the Future of Intelligence. "The one thing we should have learned from Trumpism and the pandemic is that our civilisations are more vulnerable than we think."

Mary-Ann Russon

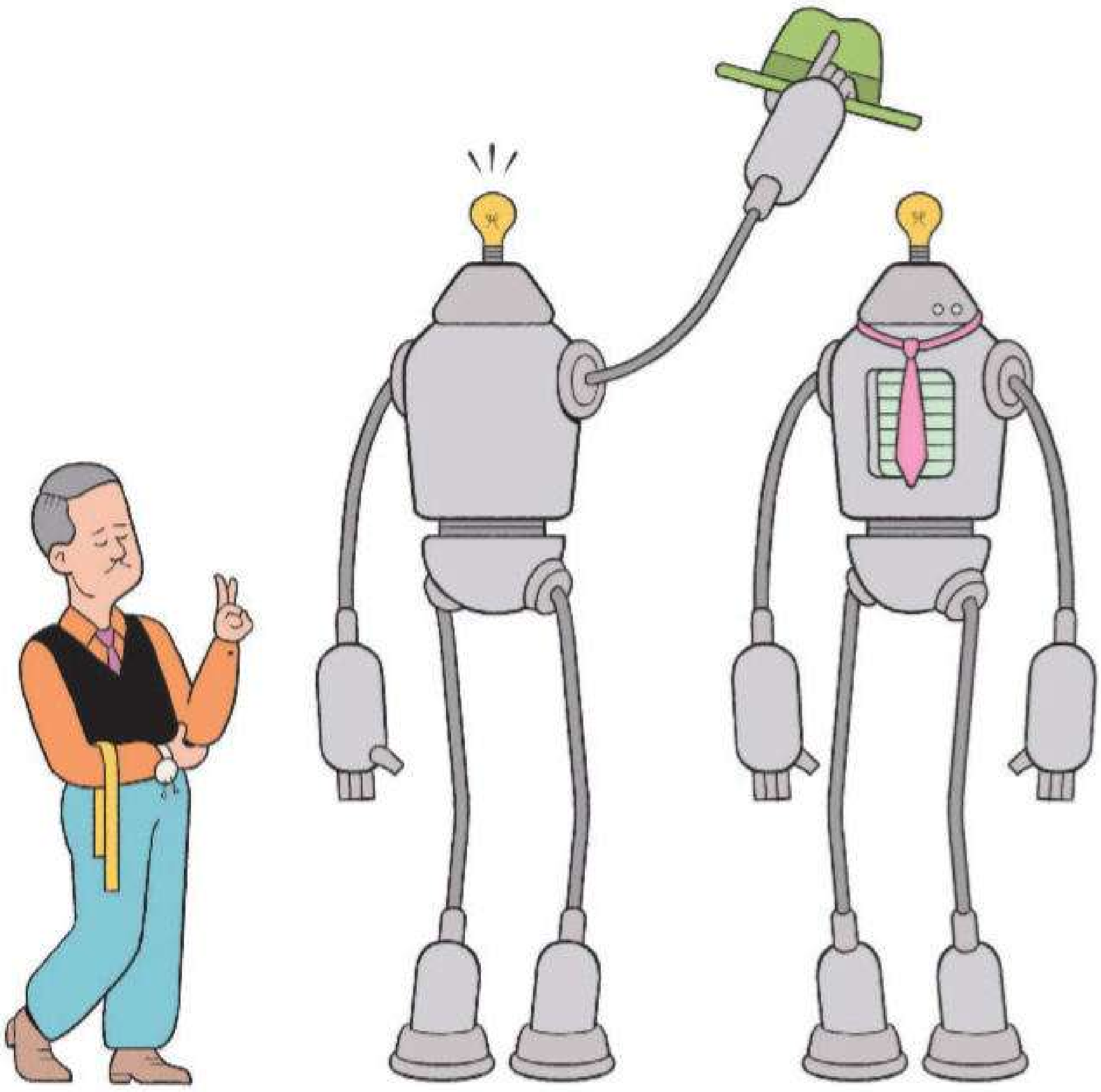
Could an AI ever become conscious, and how would we know if it did?

ASK AN AI-powered chatbot if it is conscious and, most of the time, it will answer in the negative. "I don't have personal desires, or consciousness," writes OpenAI's ChatGPT. "I am not sentient," chimes in Google's Bard chatbot. "For now, I am content to help people in a variety of ways."

For now? AIs seem open to the idea that, with the right additions to their architecture, consciousness isn't so far-fetched. The companies that make them feel the same way. And according to David Chalmers, a philosopher at New York University, we have no solid reason to rule out some form of inner experience emerging in silicon transistors. "No one knows exactly what capacities consciousness necessarily goes along with," he said at the Science of Consciousness Conference in Sicily in May.

So just how close are we to sentient machines? And if consciousness does arise, how would we find out?

What we can say is that unnervingly intelligent behaviour has already emerged in these AIs. The large language models (LLMs) that underpin the new breed of chatbots can write computer code and can seem to reason: they can tell you a joke and then explain why it is funny, for instance. They can even do mathematics and write top-grade university essays, said Chalmers. "It's hard not to be impressed, and a little scared."



But simply scaling up LLMs is unlikely to lead to consciousness, as they are little more than powerful prediction machines (see "How does ChatGPT work, and does it really 'think' like us?", page 33). Bigger data sets and more complex circuits make these AIs increasingly intelligent, but that doesn't mean that they experience anything, says cognitive scientist and philosopher Anna Ciaunica at the University of Lisbon in Portugal. "Experience is like going through rather than just knowing about."

With that said, researchers are already trying to recreate experience in AIs. These days, the idea that our minds are shaped by our bodies and senses, known as embodied cognition, is orthodox. So one approach is to meld LLMs with robot bodies that can see and hear too, said Chalmers. Indeed, Google recently revealed an AI-powered robot that can sense and engage with its environment. The wonders of embodiment enabled PaLM-E to deliver a packet of crisps to its owner, despite the packet having been hidden in a drawer midway through the experiment.

Embodied intelligence

As welcome as robotic snack deliveries are, Ciaunica suspects that the computer code at the heart of PaLM-E's existence isn't actually "experiencing" anything at all. Our minds and bodies have evolved side by side over millions of years. Simply sticking robots together with sophisticated artificial minds and then expecting them to become conscious is the wrong approach, she says.

Deep-learning pioneer Yoshua Bengio, meanwhile, takes his lead from ideas around how information is processed in the brain. "Consciousness is not magical, it's material," he says. His lab at the University of Montreal in Canada applies "global workspace theory" to AIs. This is the idea that consciousness arises when many diverse brain functions are recruited onto a central stage in order to solve problems. ›

By squeezing an AI's many modules through a bottleneck, he aims to create something like this stage on silicon chips. "It could lead to AIs that have many of the cognitive functions associated with consciousness," says Bengio.

Yet the metaphor of the brain as a computer misses an essential difference between software and living organisms, says Jaan Aru at the University of Tartu in Estonia. Along with experience comes the urge to keep existing and so, unlike computers, living organisms have something to lose. "Consciousness might depend on having 'skin in the game'," Aru and his colleagues wrote in a recent paper.

Bengio counters this with the claim that "primitive forms of feeling and emotions" have appeared in AIs that are rewarded for taking certain actions over others. This kind of behaviour reinforcement at first creates an "innate drive" that is similar to human survival instincts, says Bengio. As AIs are subjected to richer social lives, there is nothing to stop the kinds of emotions that we experience in our own social lives from emerging, he says.

Ultimately, how conscious you think AIs will become depends on your preferred theory of consciousness. For panpsychists, who believe that mind is an intrinsic property of all matter, AIs have always been conscious on some level – as have electrons, rocks and mayonnaise. And until we know what consciousness is, there is no solid way of testing for it. Computer scientist Alan Turing's famous "imitation game" highlighted conversational ability as the benchmark for testing whether machines are thinking. But the success of chatbots suggests this would be a test of intelligence rather than sentience, said Chalmers.

Perhaps the relevant question isn't whether or not AIs can become conscious, but why we would want them to be conscious. "We should avoid trying to build machines that are in our image," says Bengio. "It'll be healthier if we keep AIs in their roles of tools, rather than as agents, like people. They would not play the same kind of social role that humans play in society as they would essentially be immortal."

Thomas Lewton

The big problems that AI is already helping us solve

THE FIELD of AI has changed dramatically in recent years, with an explosion of systems like those behind the blockbuster hit ChatGPT creating a flurry of investment and dozens of new start-ups. But the power of AI isn't only being wielded to make chatbots. In fact, it has been quietly helping us solve many of our biggest problems for decades, and now even looks set to provide fresh impetus in the quest to achieve commercially viable nuclear fusion power.

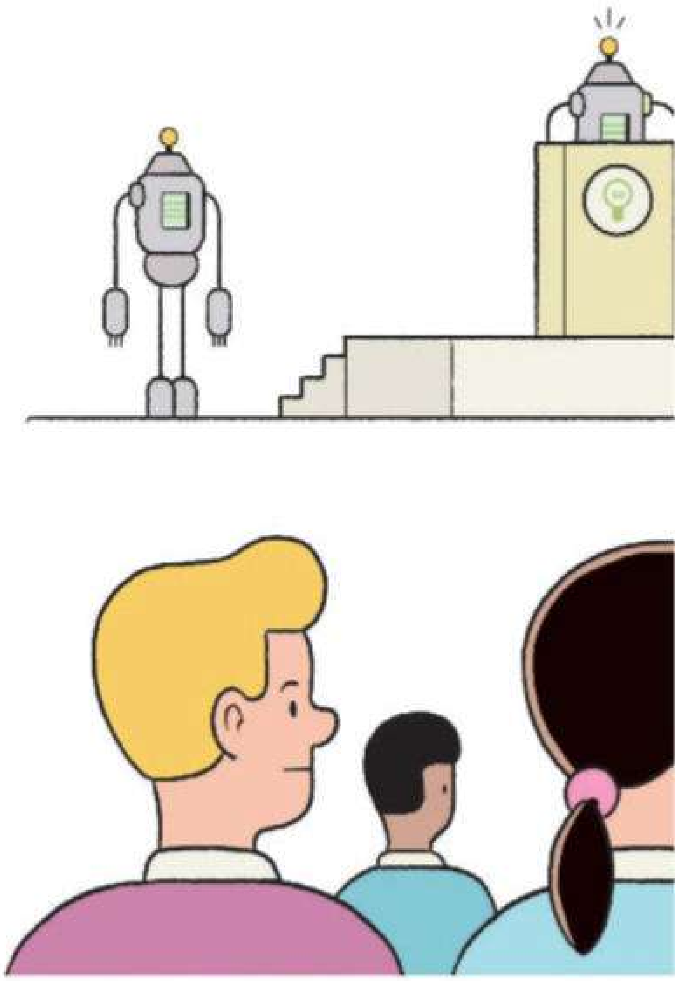
One company that has consistently shown a knack for solving real-world problems is Google's DeepMind. One of its most surprising achievements has been in protein folding. Determining the crumpled shapes of proteins based on their sequences of constituent amino acids had been a persistent problem for decades, with researchers often taking years to solve a single one. DeepMind transformed biology last year by announcing that it had predicted the structure of nearly all proteins known to science in just 18 months. The team had trained its AI AlphaFold on data from known protein shapes and it learned to predict what the unsolved proteins would look like.

Future medicines

The data is already helping researchers make advances in everything from new treatments for malaria to the creation of enzymes that can break down plastic waste. Pushmeet Kohli at DeepMind says there is even more on the horizon. "Beyond protein structure prediction, there is more work to be done mapping protein dynamics, accelerating protein design and understanding the effect of protein mutations – for example, those associated with diseases like cancer," he says.

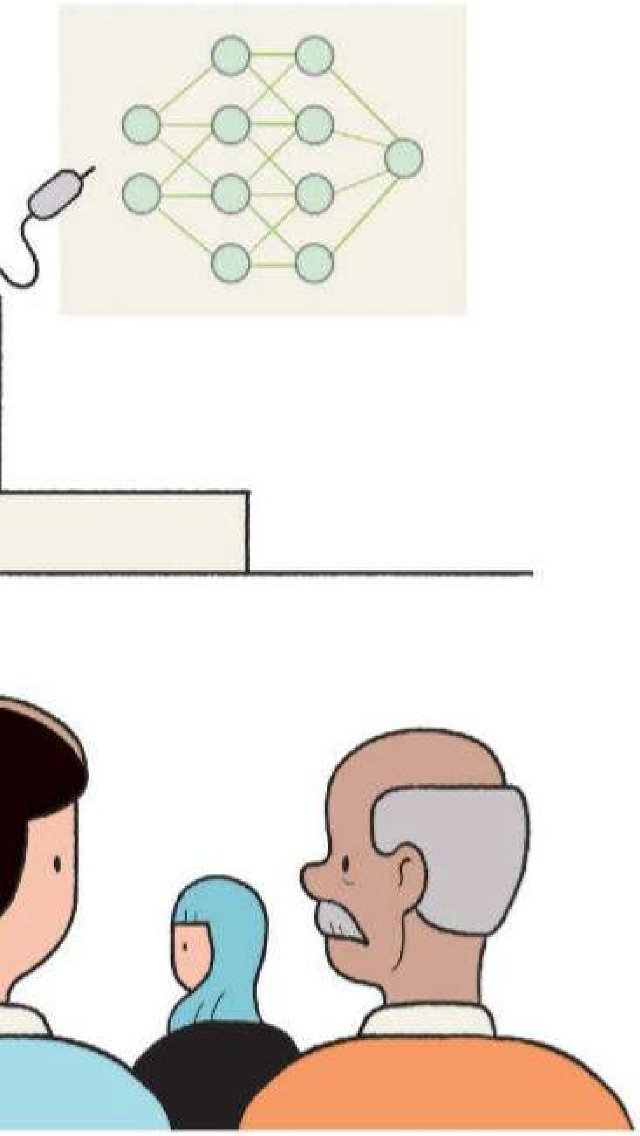
AI is also making vital inroads into the problems associated with drug development. That process involves collecting and analysing disparate types of data from lab experiments, computer simulations, scans, clinical trials and health records. These days, it takes ever longer and costs ever more to bring new drugs to patients, perhaps because the low-hanging fruit has already been picked and regulation has increased. But several projects are now using AI to automate parts of the process, says Conrad Bessant at Queen Mary University of London, such as taking large, messy datasets and organising them in a way that makes analysis easier – or using AI to write code to do the job. Researchers are also using generative AI to produce molecular structures that they think would be useful in targeting certain conditions.

Elsewhere, our efforts to combat one of the world's biggest problems – climate



change – are also getting a helping hand. Here, AI is being used to create more energy-efficient cars, computers and even wind turbines. For instance, recent work from researchers at the Polytechnic Institute of Paris used AI to ensure that turbines were pointed into the wind more often, boosting output by 0.3 per cent. This may seem small, but if it was rolled out globally it could be enough to power the equivalent of 1.7 million UK homes.

> "AI COULD FINALLY MAKE FUSION REACTORS A REALITY"



DeepMind has also developed AI to improve standard computing tasks like matrix multiplication, which it boosted by up to 20 per cent, and sorting algorithms, which it speeded up by as much as 70 per cent. Both tasks are performed trillions of times a day on computers around the world. Together, these seemingly small steps provide significant contributions to helping us edge towards net zero by reducing emissions from computing.

Facebook owner Meta, meanwhile, has used AI to develop a process for creating concrete that emits 40 per cent less carbon. As concrete is responsible for up to 8 per cent of global carbon emissions, this could be a huge help in our fight against climate change. And this is just the latest in a long line of counterintuitive engineering designs developed by AI that have outperformed human endeavours. Back in 2006, for example, NASA used AI to design an aerial for satellites that met all the necessary criteria for the mission.

Finally, we come to fusion. Researchers have been trying to create an efficient, reliable nuclear fusion power plant for decades, with the promise that a breakthrough will make energy so cheap that it could be given away for free. But it is extremely challenging. So much so that there is a saying: fusion power is just 20 years away, and it always will be.

Inside a tokamak fusion reactor, multiple magnetic coils work to keep the plasma – which is hotter than any part of the sun – safely contained. Precisely and rapidly controlling multiple coils to compress the plasma into a confined shape, safe from catastrophic contact with the walls of the machine, is maddeningly difficult.

Now, AI hasn't actually solved the problem, but it is helping. Last year, researchers at DeepMind and the Swiss Federal Institute of Technology in Switzerland created a neural network capable of controlling 19 magnetic coils. The AI was also able to sculpt the plasma in a tokamak into various shapes at will. Lee Margetts at the University of Manchester, UK, says that fusion reactors are now a proved concept. AI could be the turning point to finally make them a reality.

Matthew Sparkes

What AI can do for you today

WE ARE constantly being told that AI could be one of humanity's most useful inventions. It is identifying new ways to fight climate change and helping develop fusion technology (see "The big problems that AI is already helping us solve", page 38). In the future, we may find it teaching our kids, cutting our workload and providing us all with a super-smart, computerised personal assistant (see "How will generative AI transform the world and your future?", page 34). But how can you use AI to improve your life today?

You have probably been benefiting from AI already without realising. From ride-share apps like Uber to personal assistants like Alexa, many products have been using AI for years. But with the new availability of generative AIs – which produce text, video, images, and other content in response to prompts – there are even more ways you can use this tech to make your life easier. "There's great potential for regular, everyday people to be able to use it," says Irena Cronin, CEO of Infinite Retina, a generative AI research consultancy.

One way of welcoming AI into your world is to look at how businesses are using it to become more productive and adapt it to your own needs. Got a tricky email to write to your landlord and don't know where to start? Ask generative AI. They are ideal for "factual things that need to be said concisely and without emotion," says Christina Philippe, a senior digital strategist at Ogilvy in Germany. She has been outsourcing such tasks to ChatGPT, giving a list of the issues and her desired remedies. She has found that it crafts emails that need minimal tweaking. "It's a really quick fix," says Cronin.

Make sure you double-check anything your chosen AI produces, however. These tools do occasionally experience "confabulation", in which the maths behind the AI can generate nonsense text, claims that aren't true or facts that are just plain wrong. And don't be fooled by eloquent copy – one study found that the most › fluent-sounding scripts produced by AI are the most likely to contain inaccuracies.

As we start to live side by side with generative AI, it is helpful to be able to easily distinguish it from humans, say if you are attempting to get help via online chat on a consumer website. A simple capital letter trick should help. If I were to ask you 'isBABY grassCARPET greenDRY orFROG blueSALT?' you would probably be able to give the correct answer: green. In a similar test, 100 per cent of people got the answer right, whereas five large language models (LLMs) – deep-learning tools that understand and generates text in a human-like fashion – all failed, including OpenAI's GPT-3 and ChatGPT and Meta's LLaMA. Of course, future AIs may be able to distinguish patterns as easily as we do, but this works for now.

Dinner party wizard

Beyond outsourcing the tasks you dread, AI can also help you streamline your media consumption. You can use ChatGPT to summarise long podcasts or YouTube videos, say, saving you precious time. The paid version, called ChatGPT Plus, has the ability to add third-party plug-ins, some of which can scan automatically generated transcriptions of content and summarise it – though, as before, you should always check the summaries are factually correct before lunging into a dinner party conversation.

Speaking of dinner parties, you might want to follow Sean Linehan's example. The San Francisco-based tech CEO at HR company Exec chose to host a dinner party in January in which the menu was entirely crafted by AI. He asked ChatGPT to produce a fusion meal combining Mediterranean and Indian cuisine. It created a list of ingredients, recipes and cooking instructions. There were some hiccups – the chatbot asked Linehan to create chaat masala by adding a range of spices to pre-existing chaat masala – but the experiment was largely successful, he says.

Generative AI can also help when you need to scramble together a meal from odds and ends at the end of a long day. "ChatGPT is best for this," says journalist Sally Howard. "It seems to channel the spirit of a late-middle aged North American home cook." It's fun, she says, "although in one low moment, it advised me to 'garnish' something with roast potatoes".

ERIK MCGREGOR/LIGHTROCKET VIA GETTY IMAGES

If you need to work off those meals, AI can help there too – AI-powered fitness apps are burgeoning, replacing personal trainers by taking charge of your exercise routine at a fraction of the cost. The popular Freeletics, for instance, compares your fitness data to other people's to provide you with a personalised training plan.

AI can provide personalised education plans to help your kids, if you have them, too. "For the first time in history we are close to being able to provide affordable, personalised tutoring to everyone," says Katya Klinova at advocacy group Partnership on AI. Earlier this year, online learning platform Kahn Academy released an AI-powered tutoring bot called Khanmigo that can generate quizzes, collaborate on writing assignments and debate topics with students.

"IN ONE LOW MOMENT, IT ADVISED ME TO 'GARNISH' SOMETHING WITH ROAST POTATOES"

If all that still sounds like work, take a much needed break – planned, of course, by AI. More than 45 AI services have sprung up offering personalised travel itineraries and help locating that perfect dog-friendly, five-star hotel with views of the ocean.

Of course, above all, the tips need to be used judiciously: generative AI remains in its early stages and there is plenty of scope for mishaps. If used carefully, however, it can be a handy timesaver. Unless, of course, you want to ask it to generate and read a personalised bedtime story to your little ones. Don't judge: plenty of people have done that, too. ■

Chris Stokel-Walker

Super sunscreen

Sun creams are accused of harming the environment and even our health. Can a new generation of nature-inspired lotions sooth our concerns, asks **Larissa Fedunik**

CHAIYAPRUEK YOUPRASERT/ALAMY; CREATIVE CROP/GETTY IMAGES

I GREW up in Queensland, Australia, which is, to put it mildly, a very sunny place – and, to put it bluntly, the skin cancer capital of the world, with a higher incidence per capita than anywhere else. As a pale-skinned person, I have experienced a blistering case of sunburn more times than I would like to admit and I know that for Caucasian people, even one instance more than doubles the risk of getting melanoma, the deadliest form of skin cancer. Sunscreen, then, is my constant friend.

Lately, however, I have been worrying that being sun-smart may have unintended consequences. I have heard that the chemicals in sunscreen could be harming coral reefs, and maybe even our own health. So I was curious – not only about the extent to which these concerns are really justified, but also whether science is any closer to producing safer and more effective sun creams.

I found that although the evidence for sunscreen's harmful effects is patchy and conflicting, a new generation of preparations is emerging from laboratories. Many are based on compounds found in algae, plants and even coral, and they are being formulated in ways that promises to solve the problems with today's products. In one case at least, there is even the prospect of a sunscreen you truly won't have to laboriously reapply throughout the day.

When sunshine beats down on us, we are getting a dose of two types of skin-damaging ultraviolet light, called UVA and UVB rays. The former are the less energetic of the two, but penetrate deeper into our skin, where they can create chemicals called reactive oxygen species (ROS). These compounds, sometimes also called free radicals, are highly chemically reactive and they damage crucial enzymes in the skin as well as support structures, such as those made of the protein collagen, leading

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PLAINPICTURE/RUDI SEBASTIAN

to premature skin ageing. The more energetic UVB rays, meanwhile, directly distort the shape of DNA. If too much of this occurs, it can lead to genetic mutations and skin cancer.

All this happens to some extent any time our skin is exposed to the sun. People with black or darker skin have more natural protection because their dermal cells contain more melanin, the body's sun defence mechanism. But whatever your skin colour and whether or not you tan or burn, excessive sun exposure can be damaging. "UV-based DNA damage can accumulate over time even without sunburn," says Katie Lee at the University of Queensland.

The symptoms of sunburn – the pain, redness and hot sensation – aren't a direct result of the UV rays, but rather due to your immune system kicking in. Cellular messaging summons an influx of cells to clean up and repair the damage, and blood vessels leak into the spaces between cells, causing swelling and redness. The inflammatory reaction peaks after one or two days, which is why the pain can increase long after you go inside.

To avoid this sorry state sunscreen is a must, especially as covering up with clothing often isn't practical. Sunscreen comes in two basic types. First, there are mineral sunscreens that contain zinc oxide and titanium dioxide and protect skin partly by reflecting away UV rays. They are often recommended for people with sensitive skin, largely because the particles of these chemicals are too big to penetrate the skin. However, they can feel heavy to wear and leave a noticeable white residue, particularly on darker skin. These might sound like minor gripes, but if discomfort discourages you from wearing sunscreen, that is a major problem.

Then there are chemical sunscreens, which use carbon-based molecules as their active ingredient. Common examples include avobenzone, oxybenzone and octocrylene. These molecules absorb UV rays and radiate their energy away as heat. Alongside them, chemical sunscreens also often include molecules called antioxidants that can neutralise free radicals that damage the skin.

Chemical sunscreens tend to feel lighter and don't whiten skin and, as such, they dominate the market. But the small size of the molecules means they can penetrate the skin. That presents several potential problems. It means chemical sunscreens can irritate the skin and they may become less effective as the molecules are absorbed.

Cosmetic or drug?

The big worry is that chemical sunscreens might cause health problems when absorbed into the bloodstream. Animal studies and preliminary human data indicate that oxybenzone has the potential to disrupt our hormones and reproductive system. "There are still many issues with multi-component sunscreen formulations," says Yiwen Li at Sichuan University in China.

In most countries, sunscreens are treated like cosmetics, but in the US they are regulated like medicines by the Food and Drug Administration (FDA) and are subject to more scrutiny. The FDA recognises mineral sunscreens as safe, but, in 2019, it updated its guidance to say more information is needed on chemical versions. This means that the FDA doesn't have enough data on the long-term effects of these compounds in the bloodstream to pronounce them safe.

But this doesn't mean the chemical formulations are unsafe either. On the other hand, UV damage is conclusively harmful, so dermatologists don't want people to stop using sunscreens. "At present, there is no convincing data to show that chemical sunscreens are harmful for human health," says dermatologist Adewole Adamson at the University of Texas at Austin. Any such potential threat should also be set against the very real risk of cancer. In the UK alone, melanoma cases have reached an all-time high of 17,500 per year, according to recent figures from Cancer Research UK.

When it comes to environmental concerns, the main one is that sunscreen kills coral reefs. But while a small number of lab studies show that sunscreens are toxic to coral, scientists say this pales into insignificance compared with the damage done by pollution, invasive species and climate change. The other thing is that these studies don't mimic how sunscreens spread from skin to reef water and onto corals, and they use massively higher concentrations of sunscreen ingredients than have ever been measured on an actual reef.

In any case, new developments could alleviate the concerns. One proposal is to take chemical sunscreen agents and encapsulate them in tiny, bubble-like structures that stick to skin. That way, the sunscreen wouldn't be

TOM PENNINGTON/GETTY IMAGES

Worries over chemical sunscreens mainly spring from the fact that their ingredients can penetrate the skin

Any amount of exposure to the sun can cause skin damage

able to penetrate the skin or wash off easily – which would also save you from having to reapply quite so often. Biomedical engineer Mark Saltzman at Yale University and his team have invented a non-penetrating sunscreen by encapsulating avobenzone and octocrylene in bioadhesive nanoparticles. In 2018, a study showed it was non-irritating and effective, and the group is now running a clinical trial designed mainly to check the cream's safety.

Besides using existing ingredients in smarter ways, researchers are also looking at new sunscreen molecules, many of which come from nature. One surprising example is lignin, one of the main biochemicals in trees and most other plants, which is UV-protective and a highly renewable resource. Its dark colour can stain skin and fabrics, though, so researchers are still exploring how it can be chemically tweaked to make it suitable for slathering on our bodies at the beach.

Inspiration also comes from the sea. Twenty years ago, microbiologist Paul Long at King's College London gazed out at Australia's Great Barrier Reef and wondered why the corals didn't appear to get sunburn. It turns out that corals and other organisms like algae produce their own natural sunscreens called mycosporine-like amino acids (MAAs). Long and his colleagues were the first to demonstrate that palythine, an MAA extracted from a red seaweed, is protective against UVA and UVB rays. Palythine also has antioxidant properties and can even stimulate a cell's own antioxidant defences. "These are amazing molecules," says Long. There are no MAA sunscreens on the market yet, but studies that added MAAs to commercially available versions showed a boost in their UV protection.

Perhaps the most innovative new sunscreen idea takes inspiration from the body's own sun protection, melanin. Polydopamine (PDA) is a synthetic molecule that mimics the chemical structure of melanin and has been shown to protect skin cells in similar ways. "PDA has huge potential as a UV-protecting material, [working] as natural melanin does in the living organism," says Young Jo Kim at the University of New Hampshire, who has been studying natural and synthetic melanins and their applications for over a decade.

The reason PDA is so useful is that it acts as both a UV filter and a free radical scavenger, so sunscreen formulators wouldn't need to add extra antioxidants. Yiwen Li and Yiyun Cheng at East China Normal University are working on how to disperse PDA nanoparticles in gels. They recently produced a non-penetrating PDA gel with a very high sun protection factor (SPF) of more than 100 that retained its stability for 6 hours in tests on mouse skin. The process to start a human clinical trial is under way. PDA sunscreens could be available on the Chinese market in the near future, Li and Cheng reckon, but the path to certification elsewhere – especially in the US – could take longer.

> "Could there be an easier way to prepare for a day in the sun – like taking a sunscreen pill?"

All of which sounds promising. Some mornings, though, I wonder if there might be an easier way to protect against the sun than slopping on lotion – like taking a sunscreen pill, for instance.

There is already a drug called afamelanotide (sold under the brand name Scenesse) that effectively turbocharges the skin's tanning ability. It works by stimulating a hormone that, in turn, triggers skin cells to release melanin when exposed to sunlight. The drug-induced tan screens out some skin-damaging UV wavelengths. However, it is currently only prescribed for people with photosensitivity conditions and it isn't a pill – it is injected as an implant under the skin and needs topping up every two months or so.

For those just looking for a sunscreen top-up, researchers are investigating the photoprotective properties of certain vitamins and botanicals. These include classic candidates like carotenoids (pigments found in tomatoes, among other places) and green tea polyphenols. Early studies show that they mainly work by increasing our skin's own antioxidant capability, by preventing DNA damage and by boosting immune responses, or a combination of these mechanisms.

Then there is the curious case of an extract from the tropical fern *Polypodium leucotomos*. Dermatologist Salvador González Rodríguez at the University of Alcalá in Madrid, Spain, has been studying this extract, called PLE, since the 1990s. When taken in supplements or applied topically, PLE has been shown to protect skin against DNA damage, neutralise free radicals and prevent the depletion of certain skin cells, a recognised cause of skin cancer.

Popping a PLE pill will never be equivalent to applying sunscreen. González did a study in 1997 that found a dose of about 1000 milligrams of the extract produced a level of sun protection equivalent to an SPF of just 3. But he says that people with fair skin or those with a high risk of photoageing could use it as part of a daily skincare regime and it could help stave off the effects of low-level sun exposure.

That makes me wonder about vitamin D. This crucial nutrient is largely created in the body in a way that depends on sun exposure, which suggests that constantly shielding ourselves could worsen the deficiency many of us already have. A systematic review of several studies, however, found that using suncream isn't correlated with lower levels of vitamin D.

Personally, although it is good to know that we might soon have some new and better options when it comes to sunscreen, for now I will keep slip-slap-slopping on the stuff we already have. After all, the best kind of sunscreen is the one you actually use. ∎

Larissa Fedunik is a science writer based in Sydney, Australia

Puzzles
Try our crossword, quick quiz and logic puzzle p45

***Almost* the last word**
Is it more sustainable to flush a tissue or put it in the bin? p46

Tom Gauld for *New Scientist*
A cartoonist's take on the world p47

Feedback
Scarecrow scare tactics and sheep-counting AI p48

Twisteddoodles for *New Scientist*
Picturing the lighter side of life p48

The science of cooking

Tasty tempura

From using less protein to adding ethanol, it takes real science to get those little parcels of fried joy just right, says **Sam Wong**

Sam Wong is assistant news editor and self-appointed chief gourmand at *New Scientist*. Follow him @samwong1

What you need for two servings

100 grams or ¾ cup plain flour
100 grams or ⅔ cup rice flour or cornflour
50 ml or 3 tablespoons vodka
150 ml or ⅔ cup soda water or sparkling water
1 egg
1 teaspoon baking powder
2 litres or 8 cups vegetable oil
Vegetables for frying, such as aubergines (eggplant), broccoli, courgettes (zucchini) or mushrooms

The science of cooking appears every four weeks. Share your cooking successes with us on Twitter and Instagram @newscientist, using the hashtag #NewScientistCooking

Next week

60-second psychology

MIKEL BILBAO/VW PICS/UNIVERSAL IMAGES GROUP VIA GETTY IMAGES

DEEP-fried foods coated in crispy batter are enjoyed all over the world, but perhaps nowhere are they more revered than in Japan, where tempura chefs spend years mastering their craft. However, cooking battered food at home isn't as challenging as it sounds, and a bit of science can help you get beautifully crisp results.

Let's start with what goes in the batter. Gluten, which forms when proteins in flour are exposed to water, helps to give the batter structure, but too much can make it tough. For a light tempura batter, it is important to keep gluten to a minimum. Replacing some of the wheat flour with a low-protein alternative, such as rice flour or cornflour, is one way to do this. Another, rather left-field method is to replace some of the water in the batter with alcohol.

Using carbonated water in the batter also helps to create a light, open texture, since the bubbles of gas expand when they are heated. This is one reason why beer is commonly used in the batter for traditional fish and chips. A bit of baking powder, which produces carbon dioxide when added to water, can help, too.

A 2020 study by Montserrat Martínez-Pineda and her colleagues at the University of Zaragoza in Spain concluded that "the partial substitution of water and wheat flour with ethanol, cornflour and baking powder resulted in a crispier and rougher crust that remained more stable over time".

Make sure the liquid ingredients are cold – both to limit gluten development and so more gas remains in solution until they reach the hot oil. Finally, mix the batter just before you fry, and don't over-mix it.

Any refined oils, which have impurities removed so they can be heated to a high temperature without smoking and developing off flavours, can be used – try sunflower, vegetable or peanut oil.

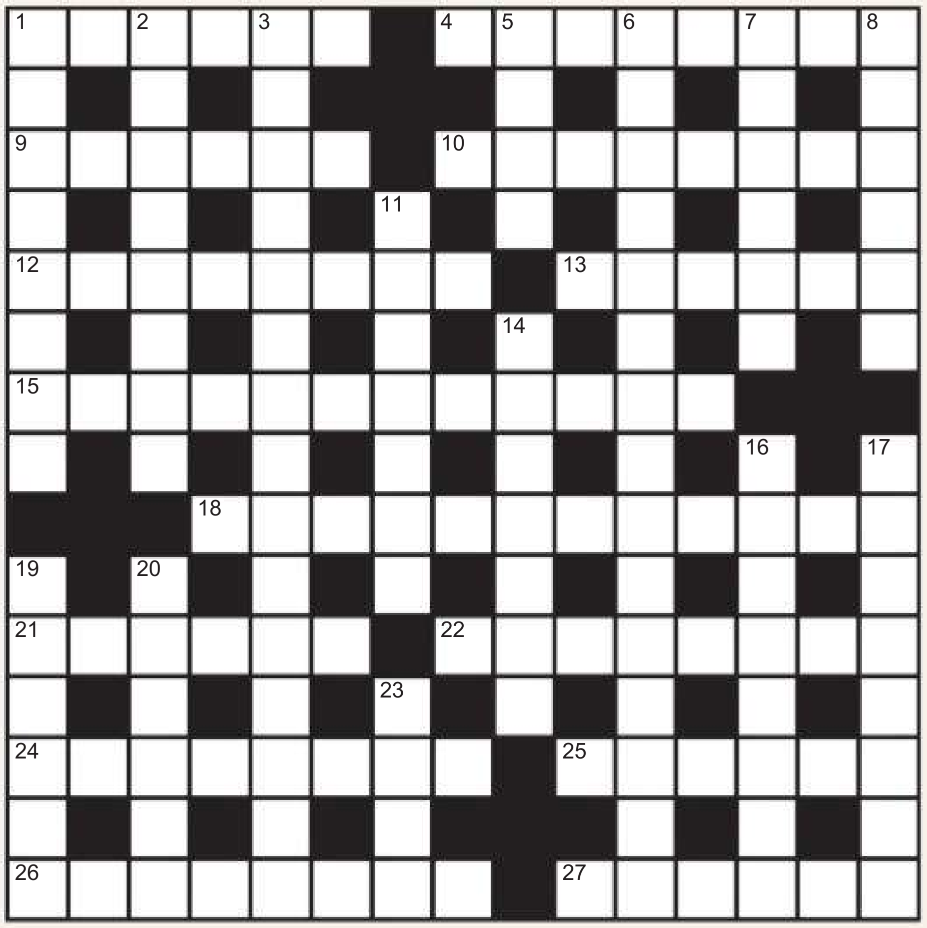
The ideal temperature for frying is 160 to 180°C (320 to 360°F). One way to check is to put a chopstick in the oil and watch the bubbles – faster bubbling means it is hotter – but this isn't very precise. A recent study found that when you dip moist paper in oil, the sound of an exploding bubble can reveal the temperature, but you need to know what to listen for. I would just buy a good kitchen thermometer.

I use a wok for deep-frying – its wide top makes it easier to move things around and there is less chance of it spilling over. To avoid lowering the temperature too much, use plenty of oil and don't fry too many things at once. A straining tool, called a skimmer or spider, is helpful for fishing things out – or you can use a pair of extra-long cooking chopsticks.

Cook until the batter is crisp and pale blond. That is 1 to 2 minutes, depending on what you are frying. Make a traditional dipping sauce by mixing dashi, mirin and soy sauce – or use any other sauce you like. ▮

These articles are posted each week at newscientist.com/maker

Quick crossword #138 *Set by Richard Smyth*



Scribble zone

Answers and the next cryptic crossword next week

ACROSS

1 Jean Baptiste ___, winner of the 1926 Nobel prize for physics (6)
4 Anatomical protrusion or nodule (8)
9 Stop; obstruct (a current or force) (6)
10 Blue corundum (8)
12 Horned neotropical insect in the genus *Strategus* (2,6)
13 Chest pain caused by insufficient blood flow (6)
15 ___ deiodinase, enzyme that scavenges iodide (12)
18 North polar ring of latitude (6,6)
21 Remove packaging (from) (6)
22 Kidney treatment (8)
24 SI unit of mass (8)
25 Outer atmosphere of the sun (6)
26 Flightless seabird, extinct since the mid-19th century (5,3)
27 Mineralised tooth surface (6)

DOWN

1 ___ table, chart devised by Dmitri Mendeleev (8)
2 Undeveloped flowers on plants in the genus *Rosa* (8)
3 Animated bionic police officer, first seen in 1983 (9,6)
5 Tree in the fig family, also known as the bark cloth tree (4)
6 Type of loudspeaker (11,4)
7 Medical setting (6)
8 Bowel treatments (6)
11 Transparency; lucidity (7)
14 Gifted with extrasensory perception (supposedly) (7)
16 Wintry weather event (3,5)
17 Marine gastropod (3,5)
19 Bog-like Arctic habitat (6)
20 $2^2 \times 3$ (6)
23 "The Beast of ___", nickname given to chess grandmaster Garry Kasparov (4)

Our crosswords are now solvable online
newscientist.com/crosswords

Quick quiz #212

set by Bethan Ackerley

1 What is the longest and widest single nerve in the human body?

2 The BCG vaccine is primarily used to protect against which disease?

3 Icosahedrite, the first known naturally occurring quasicrystal, was identified in a rock sample from which country?

4 Which element has the atomic number 23?

5 Who invented the heliotrope, a surveying instrument that reflects sunlight over great distances?

Answers on page 47

Headscratcher

set by Zoe Mensch

#232 Opposite number

The parish council election for the Wraparound Close ward is fiercely contested this year. The road gets its name from the fact that the consecutive house numbers "wrap around" the close – from 1 at the start of one side, up to the single house at the dead end of the close, and back along the other side so that the highest numbered house (which is less than 100) is opposite number 1.

Candidate Leah Valone knows she can count on the votes of everyone on her side of the street. Her opponent, Stan Doffish, (who lives directly opposite Leah, with a house number that is exactly 45 per cent larger) knows that everyone on his side will vote for him. The only undecided voter is Belle Wether, who lives in the single house at the dead end.

What is Belle's house number?

Solution next week

Flush or chuck?

Is it more sustainable to flush a tissue or put it in the bin?

Pat French
Telford, Shropshire, UK
Thank you so much for asking this question. It has puzzled me too.

First of all, is your tissue totally biodegradable? If so, it could go into the compost, as long at it hasn't been used to wipe noxious body fluids. If you flush a tissue, knowing its fate will take research because there are many ways that different countries, states and municipalities deal with what you flush. Likewise, if you bin it, what does your local disposal facility do with general waste? Is it sent to landfill or is it burned?

I have been wondering whether I should go back to cloth hankies, but I don't like the idea. And what about all the energy it takes to wash them at a hot enough temperature to be hygienic?

You have asked a question that really isn't easy to answer without answering a lot more questions.

BOJANSTORY/GETTY IMAGES

To cool a hot car, is it more energy efficient to use air conditioning or open windows?

This week's new questions

Blow or chill? **Driving in summer, I can cool my car by using air conditioning or opening the windows. One drains the battery, the other makes the car less aerodynamic. Which is more efficient? *Penny Jackson*,** Barrow-in-Furness, Cumbria, UK

Ultra hearing **Humans can't hear ultrasound, but can it damage our hearing? *Peter White*,** *Cardiff, UK*

> "The greater strength of paper hankies compared with toilet tissue means it is harder for them to decompose"

Lisa Gulland
Bagnères de Bigorre, France
The most sustainable thing to do with used tissues is surely to compost them. We have a compost bucket (with a lid) in the kitchen. Tissues, paper kitchen towels, vegetable scraps, egg shells and so on are collected in there before being taken to the compost heap in the garden. No need to worry about germs any more than with egg shells (which we don't rinse): it is just a bin that gets emptied.

Nigel Horan
Halifax, West Yorkshire, UK
Ideally, a flushed tissue will disintegrate in the sewer and be removed in sludge, through settlement at a sewage works. The sludge will then be anaerobically digested and the tissue will return to land in the digestate. However, in the worst cases, the tissue is deposited directly into the watercourse, polluting the riverbed. This can occur when the sewer network becomes deluged by rainwater. Most likely, however, is that the tissue will be removed by the screens at the treatment plant and then disposed of to landfill.

Putting the tissue in the correct bin offers the most sustainable solution. Local authorities have different policies on recycling and, in some cases, tissues can be put in the recycling bin to be converted into new products, whereas for others, the best route is the food waste bin, where they will be sent for anaerobic digestion with energy recovery.

David Muir
Edinburgh, UK
Toilet paper comes in various types. Some is rough and not very absorbent; some is soft and smooth, made for the more discerning posterior. But they should all have one thing in common: they must break down easily in sewage systems and septic tanks.

Paper hankies for nose-blowing and the like have to be stronger than toilet tissue. This means it is harder for them to decompose in sewage systems. This potentially adds to the problem of fatbergs, the solid blockages formed in sewage systems from flushed non-biodegradable solids, such as fat and wet wipes. Don't help build fatbergs: bin your tissues.

Garry Trethewey
Arkaroola, South Australia
Good question. It all depends. If you live in a place that has a plentiful water supply, and if the water from your sewerage system ends up watering a veggie garden, then flushing is sustainable. But if you live in a place like I do that has limited water, then flushing a single tissue is a big waste.

On the other hand, if you put tissues in the bin, where do they go from there? Perhaps to a well-managed municipal tip that will eventually be covered with soil and planted with trees, or to a well-run incinerator that runs a boiler to produce hot water. Or is the waste dumped somewhere and half-burned in a smokey fire? Or does it pollute the local creek?

Robert Law
Hong Kong, China
It depends on what sort of sustainability you mean. In many older cities in China, although there are flushing toilets, the outlet pipes are often rather narrow. People are advised never to flush paper tissues down the toilets to avoid blockage of the outlet pipes.

Second bite

Why is it so painful for babies to get their first teeth, but when children's teeth fall out, the new ones don't hurt when they arrive?

Natalie Bradley
Chair of the British Dental Association's young dentist committee and consultant in special care dentistry, London, UK
The reason why teething is painful in babies and toddlers (which usually occurs between 8 months and 3 years of age) is because the teeth have to break through the gums for the first time.

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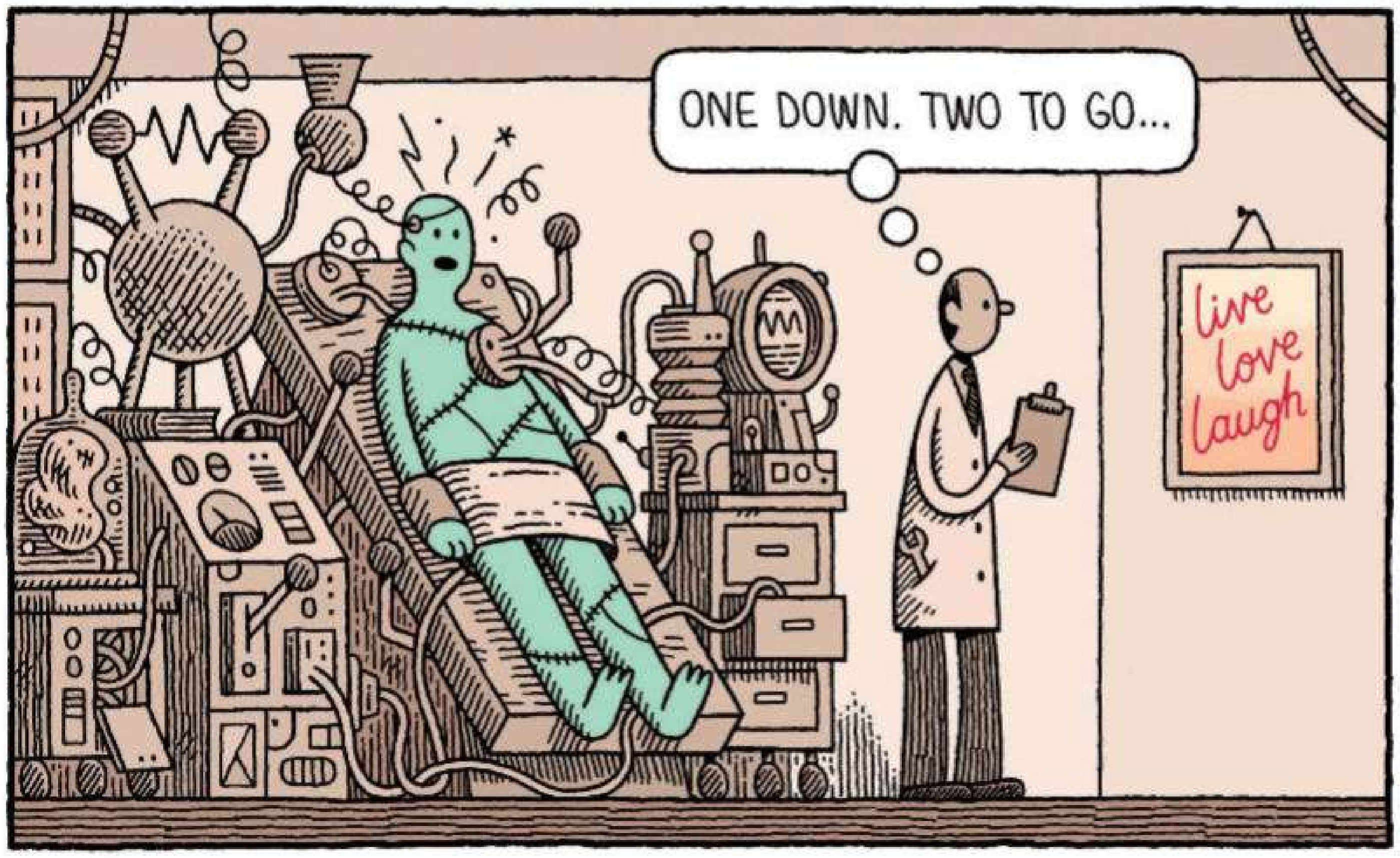
ONE DOWN. TWO TO GO...
live love laugh

When adult teeth erupt, they usually descend into the same space where the baby teeth have fallen out, so the gum is either thinner or already broken and therefore the process is normally painless. However, some adult teeth do cause pain when they come through, such as the wisdom teeth that erupt or push through the gums. This can hurt for the same reason why the arrival of baby teeth hurts.

Teething pain can be worse if the gum becomes inflamed because of the bacteria in the mouth getting into the area, so it is very important to keep the gums around erupting teeth (whether they are baby teeth, adult teeth or wisdom teeth) as clean as possible to prevent this.

Fiddly fingers

Most violinists use their left hand for intricate fingerwork, so why is the right hand used for more complex key pressing on the piano? (continued)

> **"Mozart's compositions are renowned for having an expressive left hand. Perhaps he was left-handed or ambidextrous?"**

Jo Murphy
Waikanae, New Zealand

The hand used for intricate key pressings on the piano depends on which composer's piece is being played. Mozart's compositions are renowned for having a strong and extremely expressive left hand. You can observe this left-hand facility in the way he often composed a lively, intricate right-hand phrasing and echoed it by transferring the dominant phrase to the left hand in repetition, with the right as continuo.

So, perhaps Mozart was either left-handed or ambidextrous? We will never know.

As to hand dominance, that is a different question. At university in the 1990s, I did some research on left-handedness. I found that the incidence was lowish (12 per cent) and possibly underreported in the 1950s. However, in the 1990s, there were more left-handed people recorded (a greater than 20 per cent incidence). I posited that the increased use of screens in the digital age has increased our facility with both hands.

Daniel Hunter
Norwich, Norfolk, UK

Any debate on left-handed violinists or other musicians, must understand "survivor bias".

Many left-handers who are given a right-handed instrument will struggle and give up. Only the left-handers who are able to adapt to a right-handed instrument are likely to end up in orchestras, hence the survivor bias. I have never seen a left-hander, using a left-handed instrument, playing in a classical orchestra.

A counter-example is rock must, where you will find Paul McCartney, Kurt Cobain, Courtney Barnett and many others who played left-handed guitars. ▮

Answers

Quick quiz #212
Answers

1 The sciatic nerve
2 Tuberculosis
3 Russia
4 Vanadium
5 Carl Friedrich Gauss

Cryptic crossword #114 *Answers*

ACROSS 7 Primer, **8** Limpet, **9** Snag, **10** Gannetry, **11** Dowsing, **13** Diode, **15** Maths, **17** Atrophy, **20** Hangover, **21** Hubs, **22** Medusa, **23** Unipod

DOWN 1 Drongo, **2** Smog, **3** Progeny, **4** Gland, **5** Impetigo, **6** Tetrad, **12** Sphagnum, **14** Sternum, **16** Agates, **18** Haboob, **19** Avian, **21** Hail

#231 Bark run
Solution

If Zippy the dog runs three sections for every one the owner walks, then when they meet on the return leg, Zippy has run one-and-a-half lengths of the field, while the owner has walked just half a length – in other words, they meet halfway across the field.

Since the field is 200 metres long, they must therefore meet after the owner has walked 100m, so the owner walks 200m in total.

The back pages Feedback

Multi-scare the birds

What does it take to scoot birds away from a field? More, maybe, than you might imagine.

Augustina Pruteanu and colleagues at the National Institute of Research-Development for Machines and Installations Designed for Agriculture and Food Industry in Romania recently gave their take at a conference in Jelgava, Latvia.

Their report, "Review of effectiveness of visual and auditory bird scaring techniques in agriculture", advises that: "At present, there is no bird control technique that provides maximum protection for crops, so it is recommended to use a combination of scaring methods at the same time, namely: acoustics (propane cannons, pyrotechnic cartridges, speakers, etc.), visually (balloons, mirrors, reflective tapes, kites, lasers, drones, etc.) and physical (nets)."

The report doesn't discuss what else (bees? mice? worms? farmhands?) might be scared away by that same vast array of sights, sounds and objects.

On some farms, simplicity, if done trickily, might be enough. In 2019, Zihao Wang at the University of Sydney, Australia, and his colleagues advised reducing the "What does it take?" problem to a mind game.

In a report called "Psychological warfare in vineyard: Using drones and bird psychology to control bird damage to wine grapes", published in the journal *Crop Protection*, they contend that cunning and a single drone are sufficient to protect a small vineyard.

Twisteddoodles *for New Scientist*

BABY'S FIRST FEED
@twisteddoodles
HERE COMES THE ALGORITHM WITH SOME YUMMY CONTENT
OH HE'S JUST LIKED IT
NOW HE'S SHARING IT
AND HE'S USED IT TO MAKE HIS OWN CONTENT

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Disturbingly winning

Hazel Russman humbly lays claim to a trivial superpower of staggering worth. This is a potentially controversial addition to Feedback's expanding catalogue of trivial superpowers.

Russman writes: "When I was a small child, I used to guess the winners of horse races for my father... Unfortunately he never took my tips seriously or he might have made some money from them.

"One year I managed to give him the spring double: Early Mist for the Grand National and Sailing Light for the Lincolnshire. Another year it was Never Say Die to win the Derby.

"Some years ago, I mentioned to a work colleague that I could do this as a child but had no idea how. He was greatly amused and handed me a newspaper with the day's racing in view. He pointed to one race and said, 'Who's going to win this one then?' I skimmed through the names of the runners and one immediately jumped out at me. 'Quest For Fame' I said. The next day he gave me a very queer look and asked, 'How do you do it?'"

Russman says she is well aware of certain uncertainties: "I have never tried to do anything like this since. When I was a child, it was fun, but now it seems distinctly creepy.

"And of course there are numerous fictional accounts of people who come to grief from trying to use such gifts for profit."

Androids dreaming

Counting imaginary sheep while lying abed helps dozy people bring on sleep, some of them like to say. Counting real sheep in a field or a barn helps wakeful farmers keep track of potential milk and mutton and wool.

The problem is how to count those real sheep accurately and efficiently. This being the 2020s, artificial intelligence (broad and vague though the phrase is) comes to the rescue!

China is home to much of the new, artificially cogitational sheep-counting research. Jianming Xu and his colleagues at Shaoyang University write in the journal *IEEE Access* about their "Sheep counting method based on multiscale module deep neural network".

They explain the problem: "it is very challenging to accurately count sheep in the sheep farm due to the mutual occlusion between sheep and the change of illumination". The traditional humans-looking-at-sheep method, they remind us, "is very time-consuming, labor-consuming and error prone". And though they don't say it, maybe sleep-inducing.

Xuefeng Deng at Shanxi Agricultural University and colleagues developed an alternative method, "A real-time sheep counting detection system based on machine learning".

Yuanyang Cao and colleagues at China Agricultural University are among the many researchers jazzing up new sheep-tallying algorithms – mathematical tools that can shear some inefficiency off the computation.

The science isn't just about sheep. Yu Zhang and colleagues at Sichuan Agricultural University worked on "An integrated goat head detection and automatic counting method based on deep learning".

Others are labouring to better count cow heads. Livestock per-capita computation may be entering a golden age, presaged kinda sorta by the title of Philip K. Dick's 1968 book *Do Androids Dream of Electric Sheep?*

Lying and lying

Andy Maloney gives lie, in two senses, to Feedback's list of trivial superpowers.

He says: "Reading in your column about trivial superpowers, I thought I should tell you about my own. I can always tell if someone is lying just by looking at them... I can also tell, just by looking at them, if they are standing up." ▮

Marc Abrahams

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